DEPARTMENT OF EDUCATION

GRADE 9

SCIENCE

UNIT 4

ATOMS AND THE PERIODIC TABLE

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GRADE 9

SCIENCE

UNIT 4

ATOMS AND THE PERIODIC TABLE

IN THIS UNIT YOU WILL LEARN ABOUT:

TOPIC 1: ATOMIC STRUCTURE

TOPIC 2: THE PERIODIC TABLE

Acknowledgement

We acknowledge the contributions of all Secondary Teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the Staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and editing processes, involving selected teachers of Central Province and NCD.

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DIANA TEIT AKIS
PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 -2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD

Secretary for Education

UNIT INTRODUCTION

Dear Student,

Welcome to Unit 4 of your Grade 9 Science Course! I hope that you enjoyed studying the earlier units. I also hope that this Unit, Atoms and the Periodic Table, will be an interesting and enjoyable subject to study too.

In this Unit, there are 9 Lessons on two Topics. The two topics are:

- **Atomic Structure**
- **The Periodic Table**

There are five Lessons in the first Topic. The lessons will discuss about matter, atom, elements, compounds and mixtures. It will also discuss the arrangement of electrons in shells and the chemical and physical properties of matter. You will also learn from this Topic the uses of some compounds elements and mixtures.

The second Topic is composed of four Lessons and will discuss about the Periodic Table. You will also learn from this Topic the historical development of the Periodic Table, the combining power, the difference between formulas and symbols and the properties of metals and non-metals.

Remember, you have to do all the activities and carry out the Practice Exercises after each lesson. Answers to Practice Exercises are at the end of each Topic.

If you have any problems in understanding any of the lessons in this Unit, please inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this Unit now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below and work through the lessons.

Step 1 Start with Topic 1 and work through it in order. You may come across new terms in your lessons which are written in bold with an asterisk (*) For example in Lesson 2, you will come across **electrons*.** Words like this will require you to look up their meaning in the glossary section at the end of this book.

Step 2 When you study Lesson 1, do the given Activities. When you complete the Activities, check your work. The answers are given at the end of the Lesson. (Note: Short lessons may not have an activity.)

Step 3 You will also do a Practice Exercise at the end of each Lesson. After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Topic.

Step 4 Then, revise and correct any mistake.

Step 5 When you have completed all of these steps, tick the check box for Lesson 1, on the Contents page, like this:

☑ Lesson 1: Matter

Then, go on to the next Lesson. Repeat this process until you complete all the Lessons on a Topic. When you have done this, revise using the Review Section.

Remember, as you complete each lesson; tick the box for that lesson on the Contents page. This will help you check your progress.

Assignment: Topic Tests and Unit Test

When you have completed all the lessons in a Topic, do the Topic Test for that Topic, in your Assignment Book. The Unit Book tells you when to do this. When you have completed all the Topic Tests for the Unit, revise well and do the Unit Test. The Assignment Book tells you when to do the Unit test.

When you have completed the entire Assignment Book, check and revise again before sending it to the Provincial Centre. If you have any questions, write them on the Student's page. Your teacher will advise you when he/she returns your marked Assignment.

The Topic Tests and the Unit Test in each Assignment will be marked by your Distance Teacher. The marks you score in each Assignment will count towards the final result. If you score less than 50%, you will repeat that Assignment.

Remember, if you score less than 50% in three consecutive Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all Assignments.

TOPIC 1

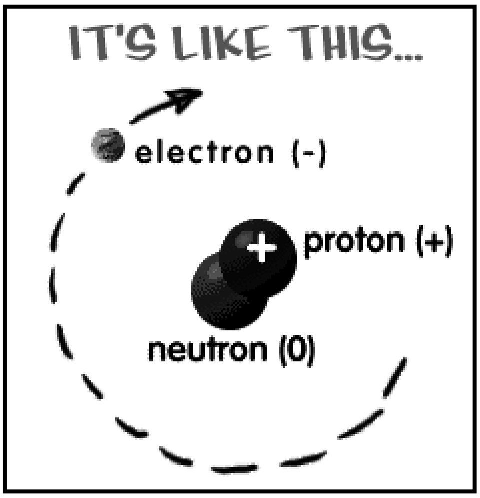
ATOMIC STRUCTURE

In this topic you will learn about:

- **matter**
- **atom**
- **elements**
- **compounds**
- **mixtures**

INTRODUCTION TOPIC 1: ATOMIC STRUCTURE

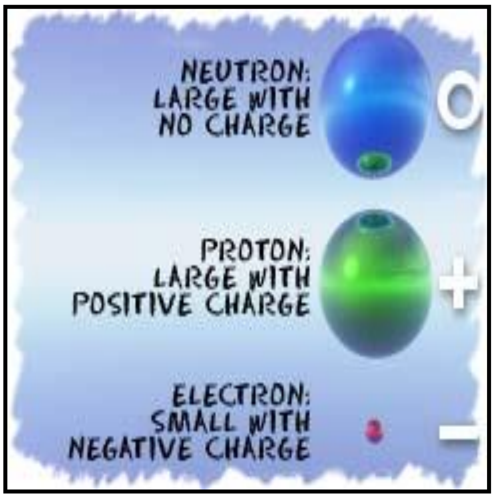
Atoms are the basis of chemistry and the basis for everything in the Universe. You should start by remembering that matter is composed of **atoms***.



Atoms and the study of atoms are a world unto themselves. We're going to cover basics like atomic structure and bonding between atoms. You will soon be learning that atoms are composed of pieces like neutrons, electrons, and protons.

There are three basic parts of an atom. The parts are the **electrons**, **protons**, and **neutrons**. What are electrons, protons, and neutrons?

A picture works best. You have a basic atom. There are three pieces to an atom. There are electrons, protons, and neutrons. That's all you have to remember. Three things! As you know, there are over 100 elements in the **Periodic Table**. The thing that makes each of those elements different is the number of electrons, protons, and neutrons. The protons and neutrons are always in the centre of the atom. Scientists call the centre of the atom the **nucleus**. The electrons are always found whizzing around the centre in areas called orbital.



You can also see that each piece has either a "+", "-", or a "0." That symbol refers to the charge of the particle. You know when you get a shock from a socket, static electricity, or lightning? Those are all different types of electric charges. There are even charges in tiny particles of matter like atoms. The electron always has a "-" or negative charge. The proton always has a "+" or positive charge. If the charge of an entire atom is "0", that means there are equal numbers of positive and negative pieces, equal numbers of electrons and protons. The third particle is the neutron. It has a neutral charge (a charge of zero).

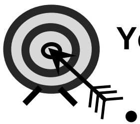
Some questions will arise such as:

- What are the different uses of elements?
- What are the properties of mixtures and solutions?
- What are the chemical and physical properties of matter?
- How could you differentiate the characteristics of elements from compounds?

In this Topic, you will find the answers to these questions and other questions relating to the atomic structure.

Lesson 1: Matter

Welcome to Lesson 1, Matter. The entire world and everything in it is made of matter. You are made of matter. The air you breathe, the food you eat and your home are all made of matter. You are surrounded by many different types of matter with many different properties and characteristics. In Grade 8 you study matter and all its physical properties in solids, liquids gases and metals. For this lesson, you will study the properties and changes of matter in its physical and chemical form.



Your Aims:

- describe the different states of matter
- describe the physical and chemical properties of matter
- describe the physical and chemical changes of matter
- identify the signs of chemical changes

Different States of Matter

Matter is anything which takes up space and has mass. We use different types of matter every day. Whenever we use something, we are using different states of matter. Properties describe matter. A block of wood, milk and air all have properties. All the material on earth is in three states-solid, liquid, and gas. The "state" of the matter refers to the group of matter with the same properties. In other words, you group the objects together according to their properties.

Solids

The wood block is solid. A solid has a certain size and shape. The wood block does not change size or shape. Other examples of solids are the computer, desk, and floor. You can change the shape of solids. You change the shape of sheets of timber by sawing it in half or burning it.

Sheets of wood

Burning of wood

Liquids

Milk is a liquid. Milk is liquid matter. It has a size or volume. Volume means it takes up space. But milk does not have a definite shape. It takes the shape of its container. Liquids can flow, be poured, and spilled. Did you ever spill juice? Did you notice how the liquid goes everywhere and you have to hurry and wipe it up?

A glass of milk

The liquid is taking the shape of the floor and the floor is expansive limitless boundary (until it hits the wall). You cannot spill a wooden block. You can drop it and it still has the same shape.

What about jelly and peanut butter?
You can spread peanut butter on bread, but peanut butter does not flow. It is not a liquid at room temperature. You have to heat peanut butter up to make it a liquid. When you or your mom makes jelly, it is first a liquid. You have to put it in the refrigerator so that it becomes a solid. These are yummy forms of matter with properties of a liquid and a solid.

Peanut butter

Jelly

Gases

Run in place very fast for a minute. Do you notice how hard you are breathing? What you are breathing is oxygen. You need oxygen to live. That is why you can only hold your breath for a certain amount of time. You cannot see oxygen. It is invisible. It is a gas. A gas is matter that has no shape or size of its own. Gases have no colour. Gases are all around you. You can feel gas when the wind blows. The wind is moving air. Air is many gases mixed together.

Gas for welding and filling toy balloon

Gas for cooking

Physical and Chemical Properties

All substances have properties that we can use to identify or describe them. For example, we can identify a person by their face, voice, height, finger prints, and DNA.. The more properties that we can identify, the better we know the person. In a similar way matter has properties. There are two basic types of properties that we can associate with matter. These properties are called physical properties and chemical properties.

Physical properties do not change the chemical nature of matter. Physical properties are readily observable like colour, size, lustre, freezing point, boiling point, melting point, attraction or repulsion to magnets, density or smell.

Chemical properties are only observable during a chemical reaction. Examples are heat of combustion, reactivity with water and pH.

Changes in Properties of Matter

Pieces of matter undergo various changes all the time. These changes are divided into the categories of physical and chemical change. Physical change does not produce a new substance. If you melt a block of ice, you still have water (H_2O) at the end of the change. If you break a bottle, you still have glass. Painting a piece of wood will not make it stop being wood. Some common examples of physical changes are melting, freezing, condensing, subliming, vaporising, breaking, crushing, cutting and bending. In all of these changes, you can get the original materials back.

Cubes of ice melting

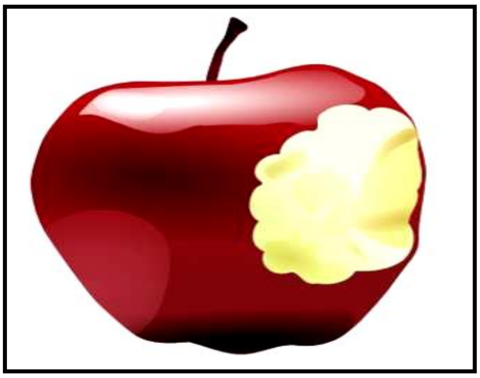
Broken bottle

A chemical change or chemical reaction produces a new substance. The new substance is different from the original. It has properties that are different than those of the starting materials. Plus, you cannot get the original materials back easily.

Examples of chemical changes include combustion (burning), digestion, respiration, photosynthesis, decomposition, cooking egg, rusting of an iron pan and mixing hydrochloric acid and sodium hydroxide to make salt and water.

A firework is a chemical change.

Signs of chemical change



1**. Colour changes** - Perhaps you have found a half-eaten apple that turns brown. The reason is that a chemical change has occurred. A change in colour is a clue to indicate a chemical change.

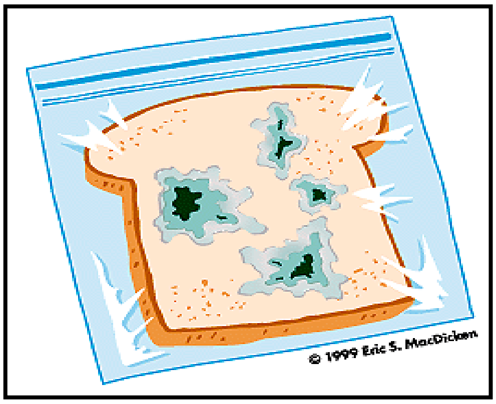
2**. Another sign of a chemical change is the release or gain of energy by an object**. Many substances absorb energy to undergo a chemical change. Energy is absorbed during chemical changes involved in cooking, like baking a cake.

- When you bake a cake, energy is absorbed by the batter as it changes from a runny mix into a cake.
- Energy can also be released during a chemical change. The fireworks that were mentioned above release energy in a form of light that you can see.

Baking a cake absorbs energy

Firework releases energy

3**. Odour changes** - When you smell an odd odour in foods such as chicken, pork of mayonnaise, you know that the food has undergone a chemical change. You can use this clue to avoid eating spoiled food and becoming ill. It only takes one experience with a rotten egg to learn that they smell different from fresh eggs. When eggs and food got bad, they undergo a chemical change. The change in odour is a clue to the chemical change.



Spoiled bread

Spoiled meat

4. Production of gases or solids

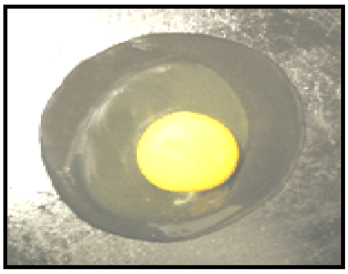
The formation of a gas is a clue to chemical changes. The bubbles of gas that you observed form when an antacid is dropped into water is an example of change. Another clue that a chemical change has occurred is the formation of a solid. A solid that separates out of a solution during a chemical change is called a precipitate.

5. Not easily reversed

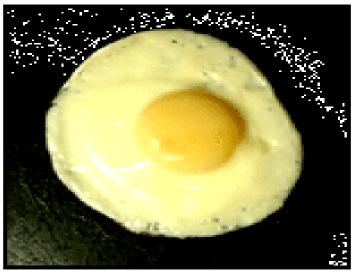
How do physical and chemical changes differ from each other? Think about ice for a moment. After ice melts into liquid water, you can refreeze it into solid ice if the temperature drops. Freezing and melting are physical changes. The substances produced during chemical changes however cannot easily change back into the original substances.

As wood burns, it turns into a pile of ashes and gases that rise into air. After the wood is burned off, it cannot be restored to its original form as a log.

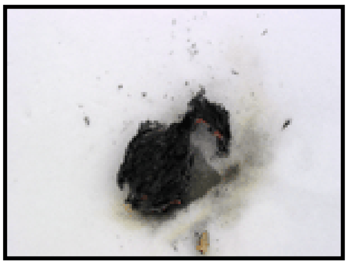
Here are other examples of chemical reactions.



Raw egg becomes cooked egg →



Paper becomes ash →



Steel becomes rust →

The most important thing for you to remember is that in a chemical change, the composition of a substance does change while in a physical change the composition of a substance does **not** change.

Activity: Now test yourself by doing this activity.

Answer all questions according to the given instructions.

A. State whether the following <u>changes</u> are physical or chemical.

1. Tearing clothes ___________
2. Tarnishing silver ___________
3. Lighting a match ___________
4. Breaking a stick ___________
5. Rusting nail ___________
6. Boiling water ___________
7. Melting ice cream ___________
8. Sawing wood ___________

B. State whether the following <u>properties</u> are chemical or physical.

1. Water boils at 100 degrees Celsius. ___________
2. Diamonds are capable of cutting glass ___________
3. Sugar is capable of dissolving in water. ___________
4. Vinegar will react with baking soda. ___________
5. Water separated into hydrogen and oxygen by electrolysis. ___________
6. Yeast acts on sugar to form carbon dioxide and ethanol. ___________
7. Wood is flammable. ___________
8. Aluminium has a low density. ___________

CHECK YOUR WORK.ANSWERS ARE AT THE END OF LESSON 1.

Summary

You have come to the end of lesson 1. In this lesson you have learnt that:

- matter is anything which takes up space and has mass.
- all the material on Earth is in three states- solid, liquid and gas.
- a solid has a certain size and shape. liquid matter has a size and volume. It takes the shape of the container.
- a gas is matter that has no shape or size of its own. It is invisible.
- physical properties do not change the chemical nature of matter. .
- chemical properties are only observable during a chemical reaction.
- physical change does not produce a new substance. A chemical change or chemical reaction produces a new substance. The new substance is different from the original.
- signs of chemical change are colour change, gain or release of energy, odour changes and production of gases or solids and not easily reversed.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

1. Describe the three states of matter.

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. Describe the physical and chemical properties of matter.

   ____

3. Describe the physical and chemical changes of matter.

   ____

4. What are the signs of chemical change?

   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity

Part A. Physical or chemical changes

1. Physical
2. Chemical
3. Chemical
4. Physical
5. Chemical
6. Chemical
7. Physical
8. Physical

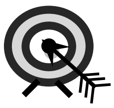
5. Chemical
6. Chemical
7. Physical
8. Physical

Part B Physical or chemical properties

1. Physical
2. Physical
3. Physical
4. Chemical
5. Chemical
6. Chemical
7. Chemical

Lesson 2: Atom

From the previous lesson, you have studied about matter. You have learnt that everything around us is made of matter. Yourself, the air you breathe, the food you eat and your homes are made of matter. You also learnt the different physical and chemical properties and changes of matter. For this lesson you will study about atom and its sub-atomic particles.



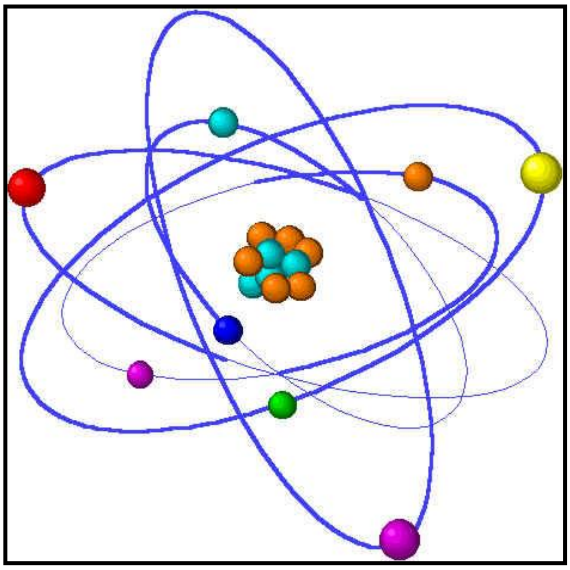
Your Aims:

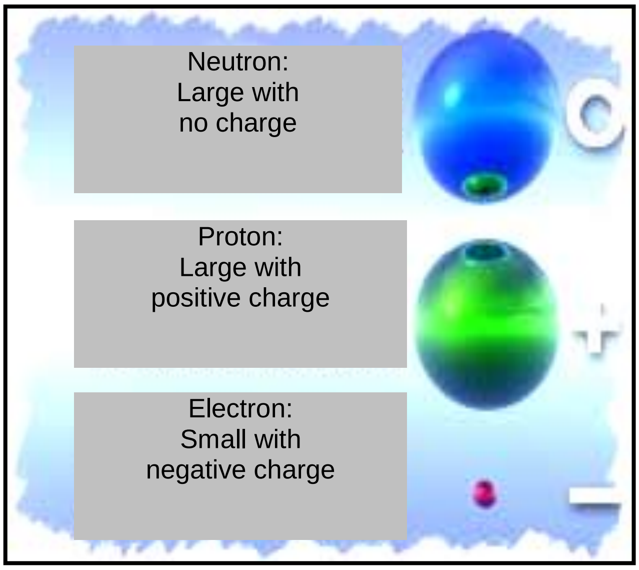
- describe atom
- describe the sub-atomic particles of atom

What is an Atom?

All matter is made up of atoms. **Atoms** are the basic building blocks of ordinary matter. Atoms can join together to form molecules, which in turn form most of the objects around you.
An atom is like a tiny solar system. In the centre of the atom is the **nucleus** which is a cluster of protons and neutrons. The **protons** have a positive electric charge while the **neutrons** are electrically neutral. The nucleus makes up almost all of an atom's mass or weight. Whirling at fantastic speeds around the nucleus are smaller and lighter particles called **electrons*** which have a negative electric charge.

An atom has the same number of electrons (-ve charge) and protons (+ve charge) to make the atom electrically neutral. An extremely powerful force, called the nuclear force, holds the protons together in the nucleus as they naturally repelled one another electrically.



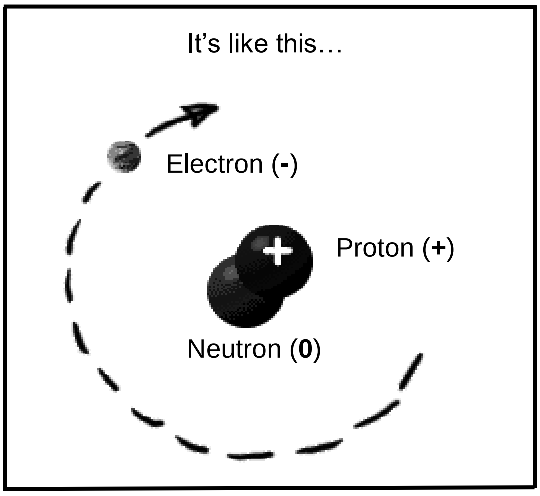


Particles of atom

What are atoms made of?

Atoms are composed of particles called electrons, protons and neutrons.These particles have different properties. Electrons are tiny, very light particles that have a negative electrical charge. Protons are much larger and heavier than electrons and have the opposite charge, protons have a positive charge. Neutrons are large and heavy like protons; however neutrons have no electrical charge.

Each atom is made up of a combination of these particles. The protons and neutrons cluster together in the central part of the atom, called the nucleus. The electrons go on circling around the nucleus at very high speeds through special tracks called orbits. This might remind you of our solar system where the planets orbit the sun. A particular atom will have the same number of protons and electrons and most atoms have at least as many neutrons as protons.



Charges of an atom

You can also see that each piece has either a "+", "-", or a "0." That symbol refers to the charge of the particle. You know when you get a shock from a socket, static electricity, or lightning. Those are all different types of electric charges. There are even charges in tiny particles of matter like atoms. The electron always has a "-" or negative charge. The proton always has a "+" or positive charge. If the charge of an entire atom is "0", that means there are equal numbers of positive and negative charges, equal numbers of electrons and protons. The third particle is the neutron. It has a neutral charge (a charge of zero).

Electron shells

Electrons are arranged in shells or orbits around the nucleus.

Maximum number

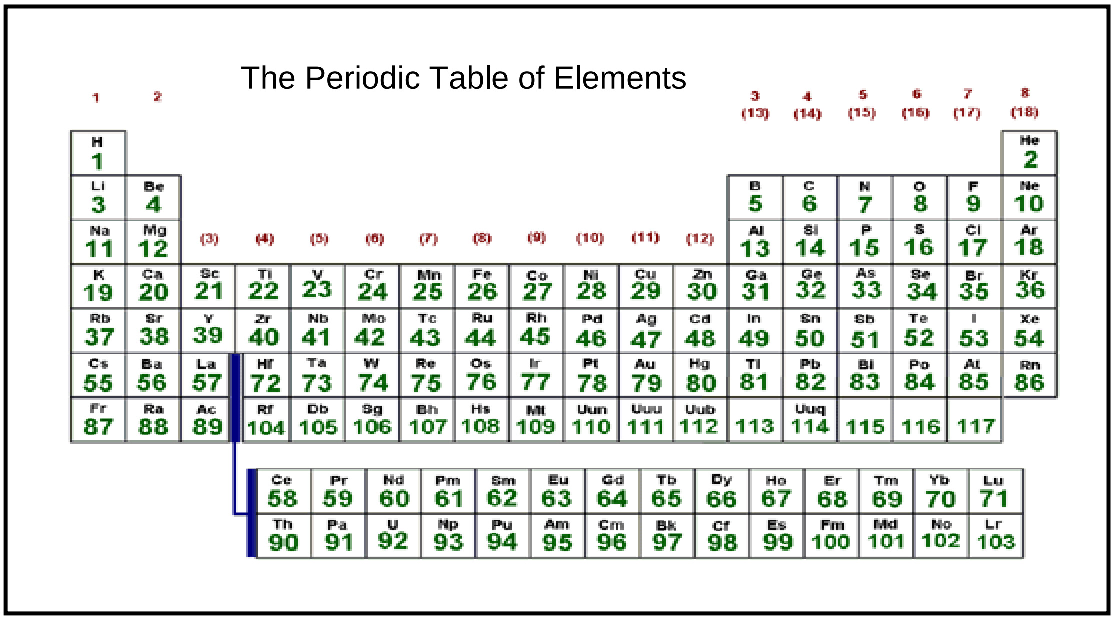
There is a definite arrangement of electrons in these shells and a maximum number of electrons possible in each shell.

Shell or Orbit Number	1	2	3	4	5
Maximum number of Electrons	2	8	18	32	50

The number of electrons possible in the first shell are 2. After the first shell is filled, the second shell starts filling up, according to the number of positive charges in the nucleus. The most allowed in the second shell is 8 electrons. Then the third shell starts to fill.

Electron Dot Structure: Shell Diagrams for the First 20 Elements
Steps for Making Diagrams

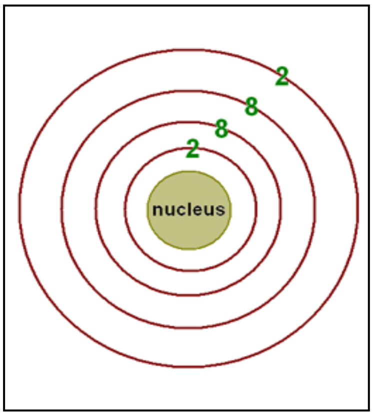
Number of Electrons: These dot diagrams are made for neutral atoms, meaning atoms that have the same number of electrons as protons. The number of protons (also called the Atomic Number) of an element makes it what it is. All we need to do is find the element on the Periodic Table and read its Atomic Number.



So for example, Fluorine has the symbol F and has 9 protons. That means this element in its neutral state has 9 electrons. For Aluminium, with the symbol Al, there are 13 protons and so we have 13 electrons.

The Filling Pattern:
Atoms can be viewed as anions. The nucleus is a solid core, and that core is covered by shells of electrons. Just as the outside layer of an onion is the only one that goes brown, so it is only the outer shell of an atom that reacts with other atoms. It makes sense then that we need to know how many electrons fit into each onion like shell surrounding the nucleus.

The pattern is 2, 8, 8, 2 for the first four shells. It is important to realise that this only applies for the first 20 **elements***. We need to be able to split the number of electrons an element has into four layer.The trick with this is to start closest to the nucleus and work your way outwards. The first shell holds 2 electrons and then is completely filled. The second holds 8, the third holds 8 and after this there are only 2 left over for the fourth shell. Of course the fourth shell can hold more than 2 electrons but we are limiting ourselves to the first 20 elements.



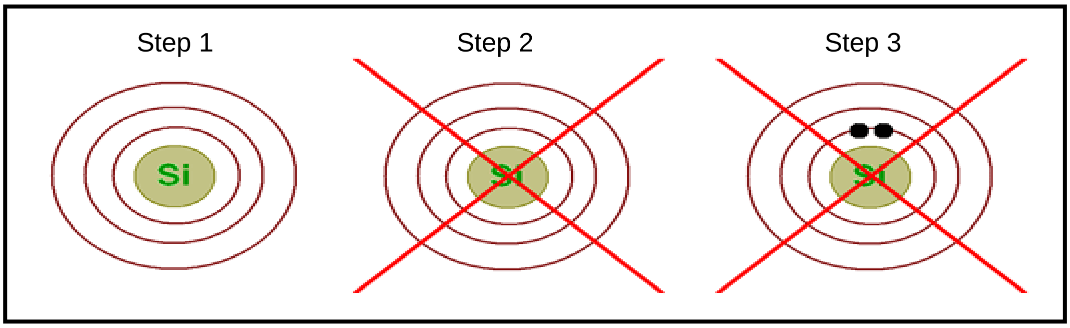
So let us consider Fluorine again. It has 9 electrons. 2 fit in the first shell, leaving 7. Then all 7 can be filled into the second shell, giving an electron dot structure of 2, 7. Silicon has 14 electrons and so has an electron arrangement of 2, 8, 4.

Making A Diagram:
Once we know the numbers of electrons in each layer, all we need to do is draw them onto simple illustration of an atom. I will use Silicon as the example in the following steps.

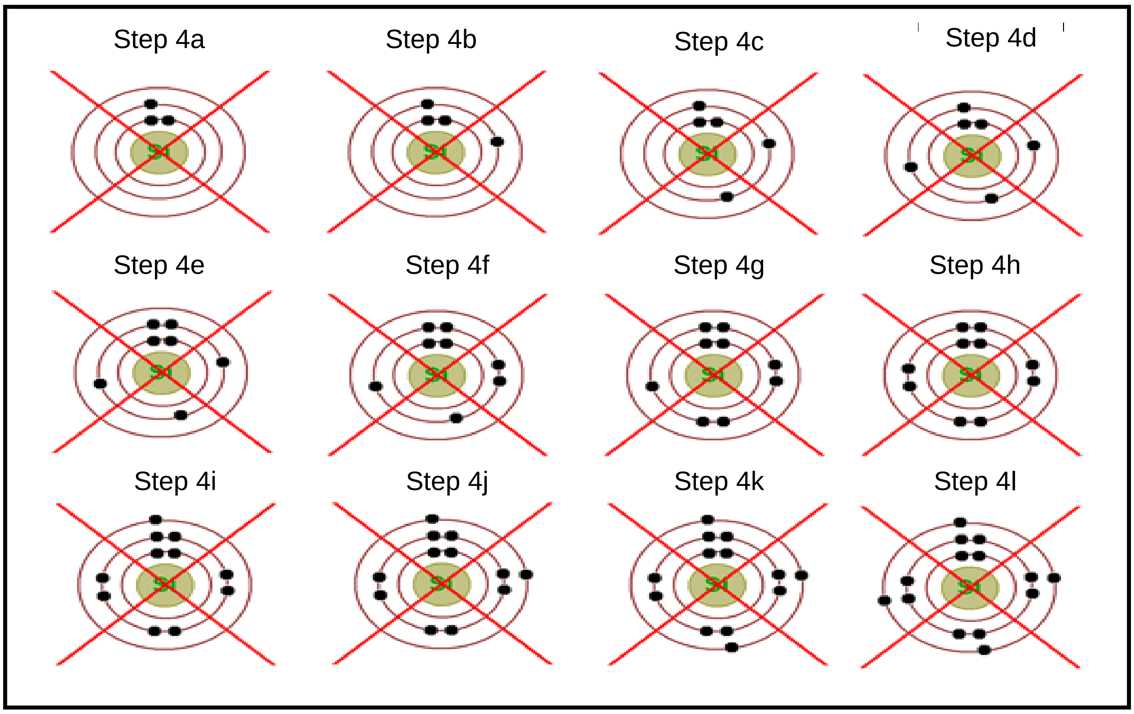
Step 1: Draw a blank atom with the required number of shells around the nucleus. In the case of Silicon that is three shells, as we know the arrangement is 2, 8, 4.

Step 2: Draw a big red "X" through the middle of the picture. This splits the electron shells into quarters.

Step 3: For the first shell, both electrons go in the **top quarter.**

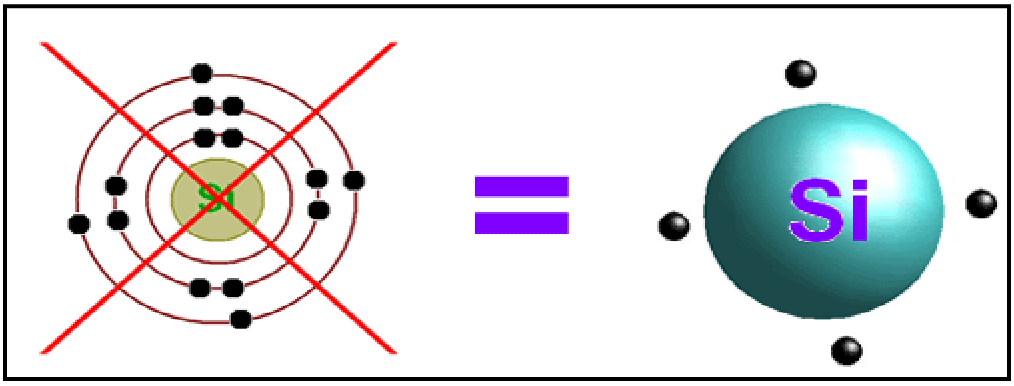


Step 4: For all other shells, start at the **top quarter** and place one electron in each quarter, moving around clockwise until all the electrons for that shell are used up. Then proceed to the next shell until there are no electrons remaining.



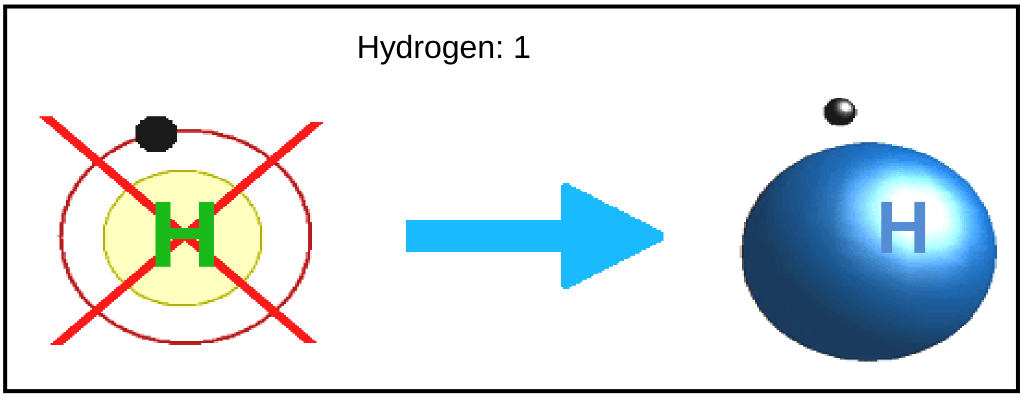
Of course it is not necessary to redraw the picture with the addition of each electron. That was done to show the process as it unfolds.

Step 5: Redraw the atom showing the **outermost shell only**. This is now the Lewis dot or electron dot structure of that element.



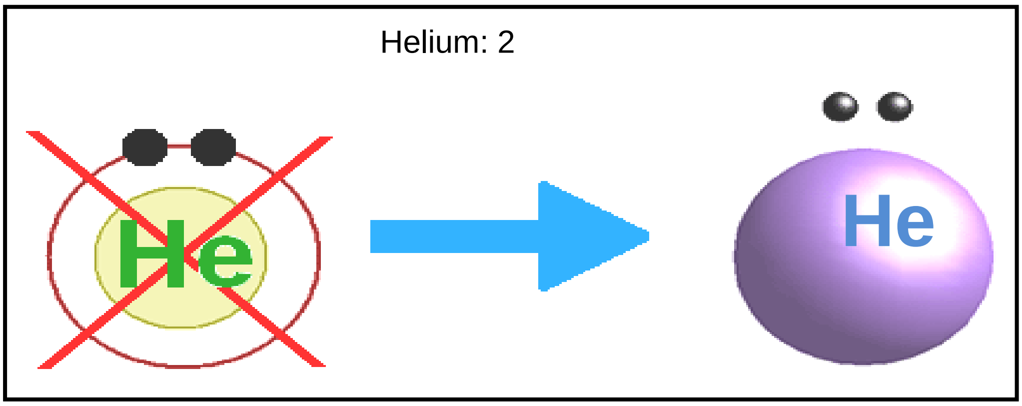
Here is the electron dot structure for each of the first 20 elements. Only the last stage of each diagram is given, and then what it looks like when redrawn only with the outer shell.

Hydrogen: 1 electron

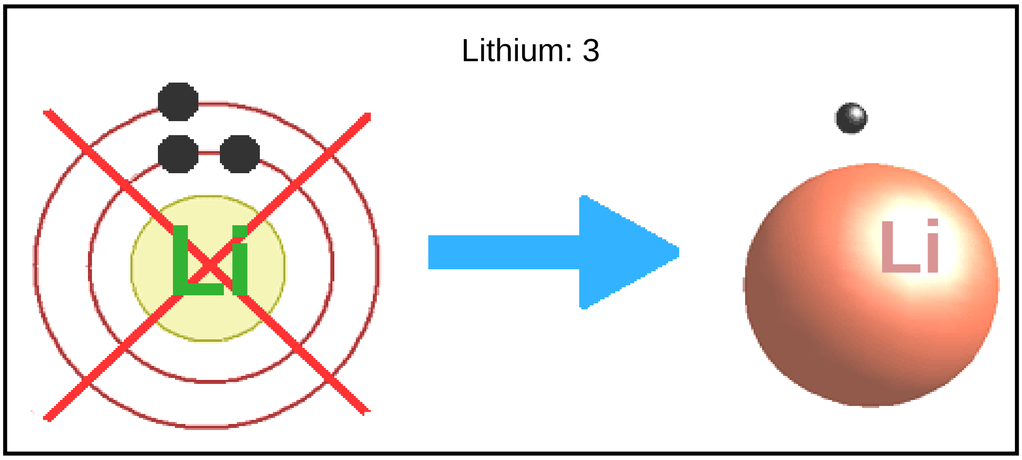


Helium: 2 electrons

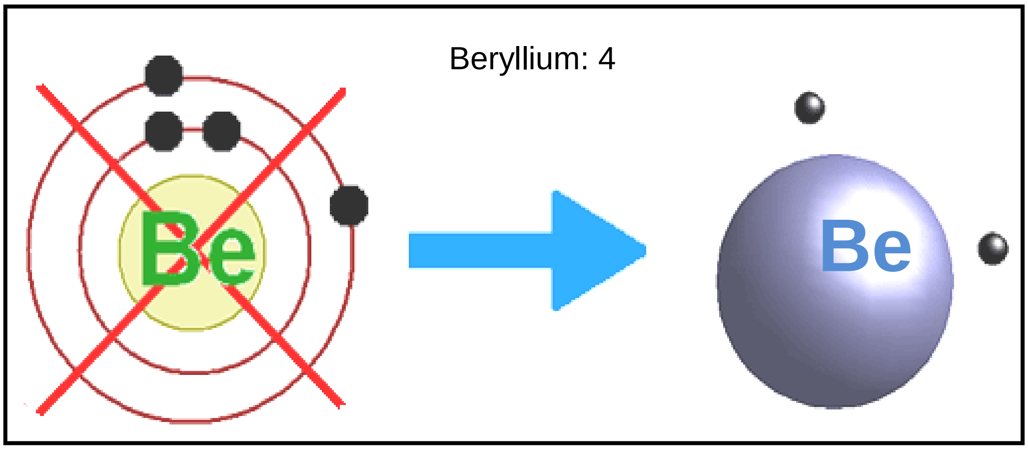
Note that the two electrons in the first shell are put in the same quarter. This shows that they form a full pair and that there is no opportunity for the atom to bond with any other elements.



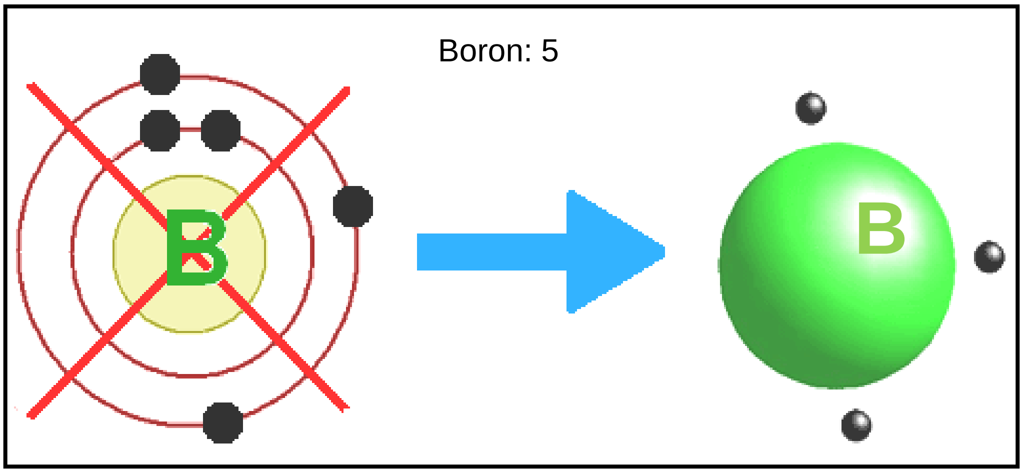
Lithium: 3 electrons. On the right of the image below, only the **outermost** shell is shown.



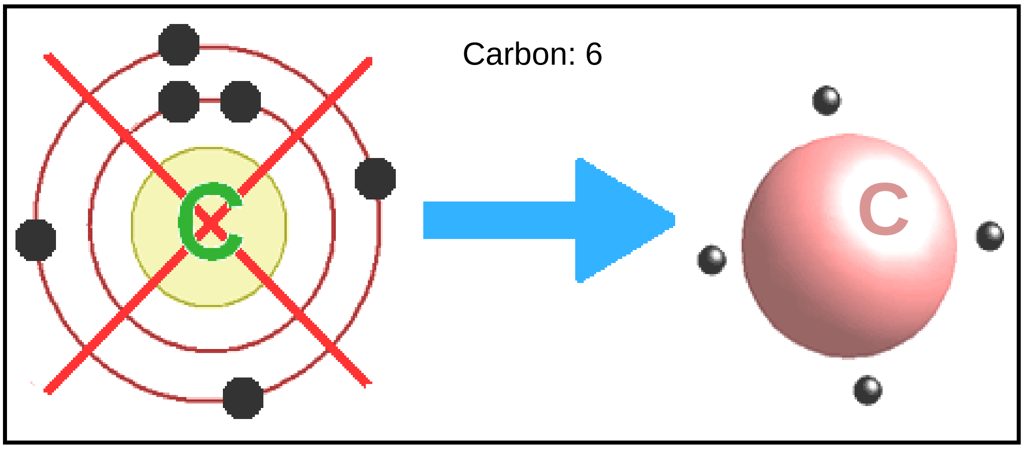
Beryllium: 4 electrons



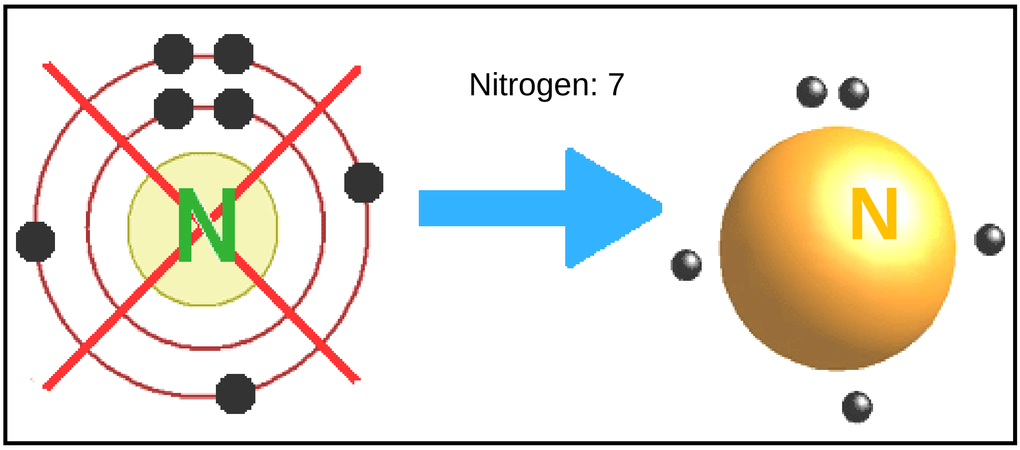
Boron: 5 electrons



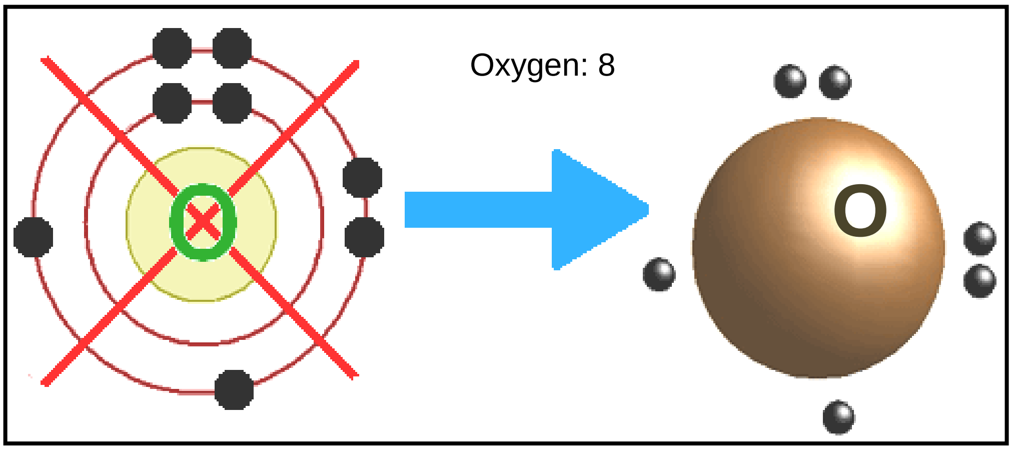
Carbon: 6 electrons



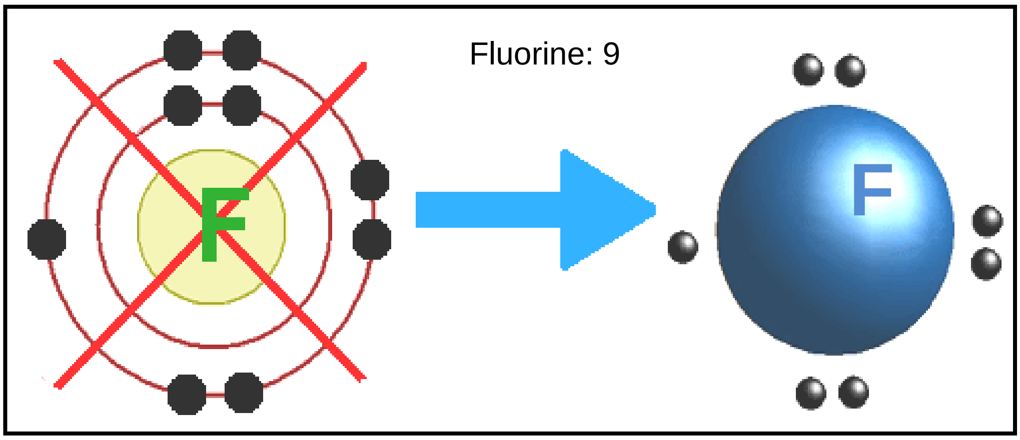
Nitrogen: 7 electrons



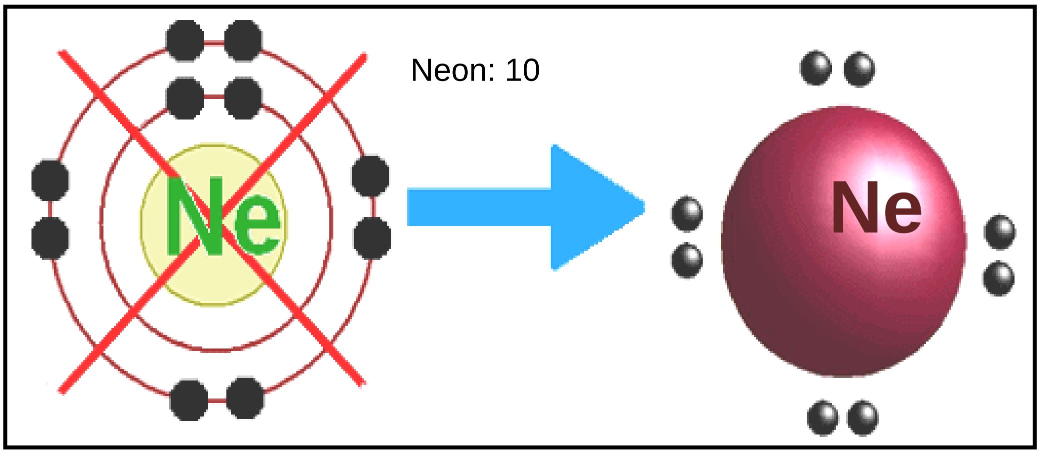
Oxygen: 8 electrons



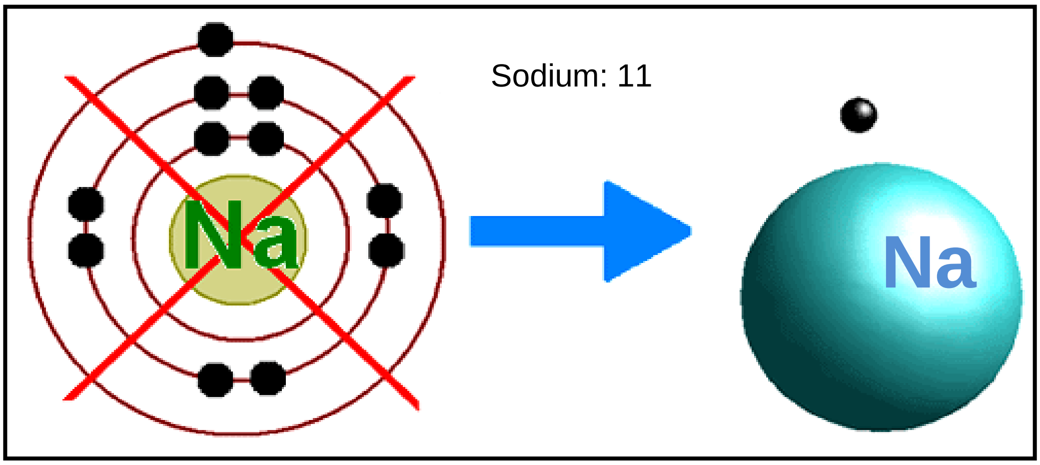
Fluorine: 9 electrons



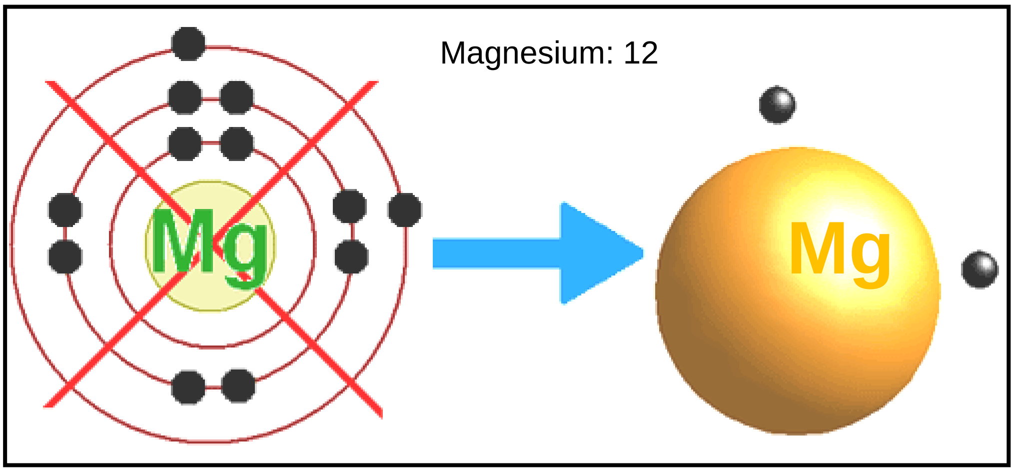
Neon: 10 electrons



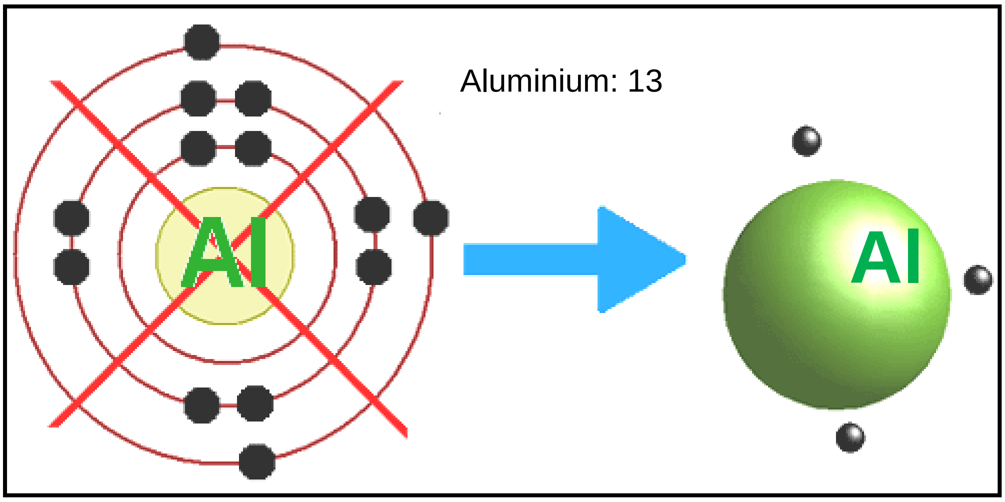
Sodium: 11 electrons



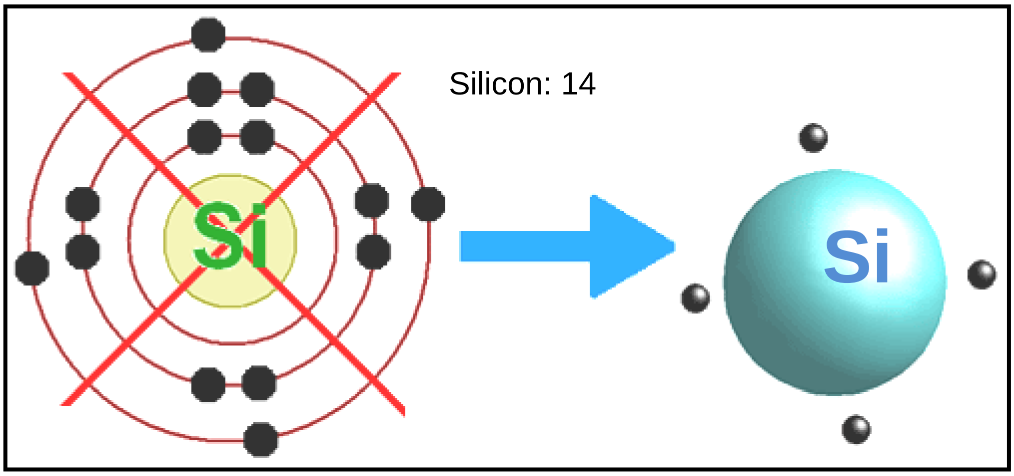
Magnesium: 12 electrons



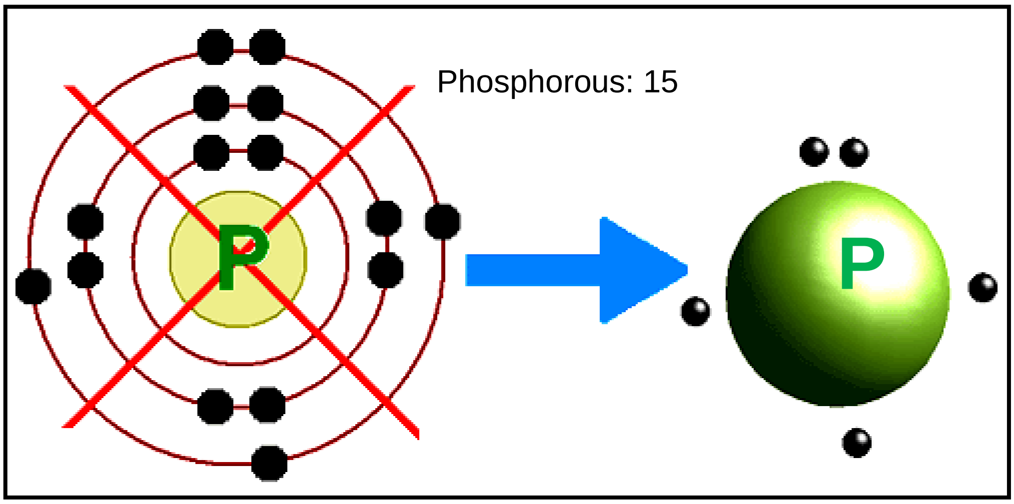
Aluminium: 13 electrons



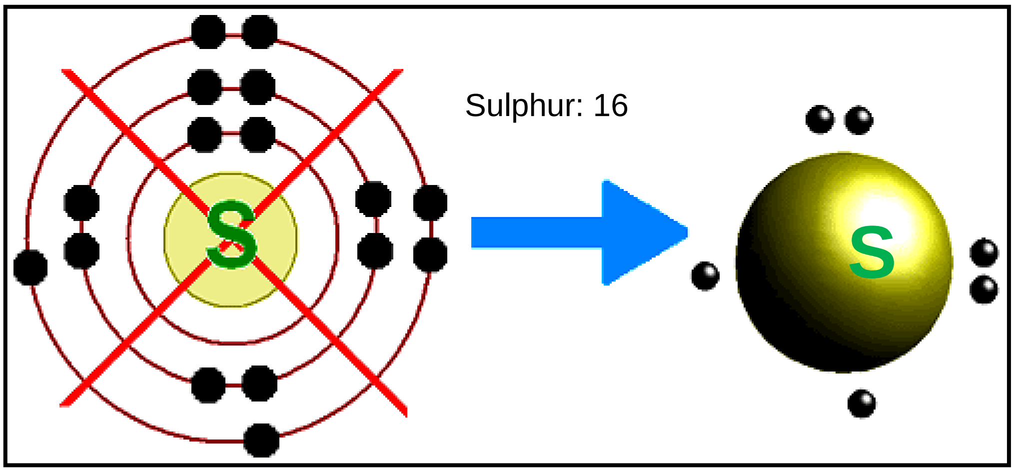
Silicon: 14 electrons



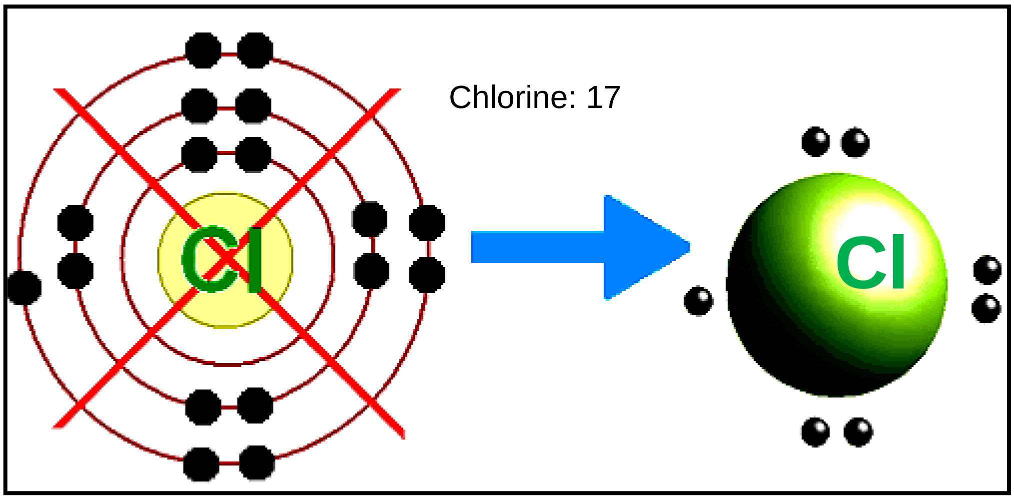
Phosphorous: 15 electrons



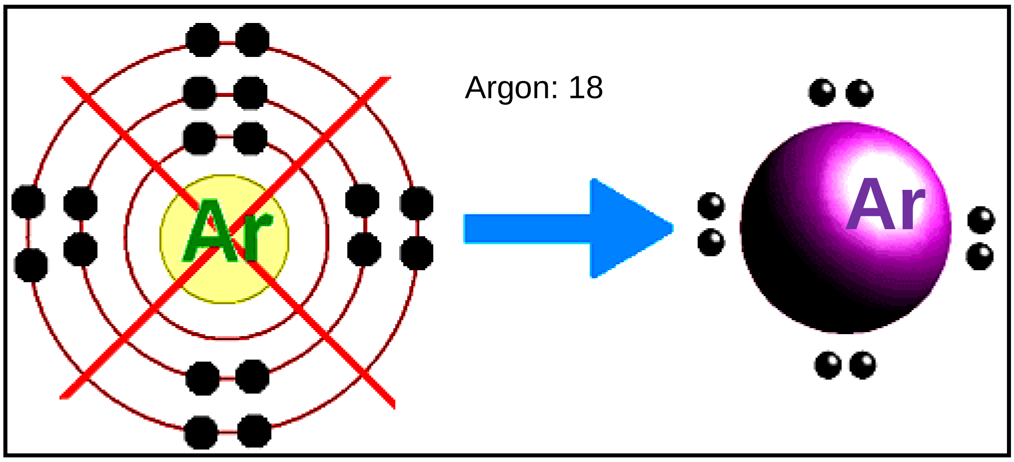
Sulphur: 16 electrons



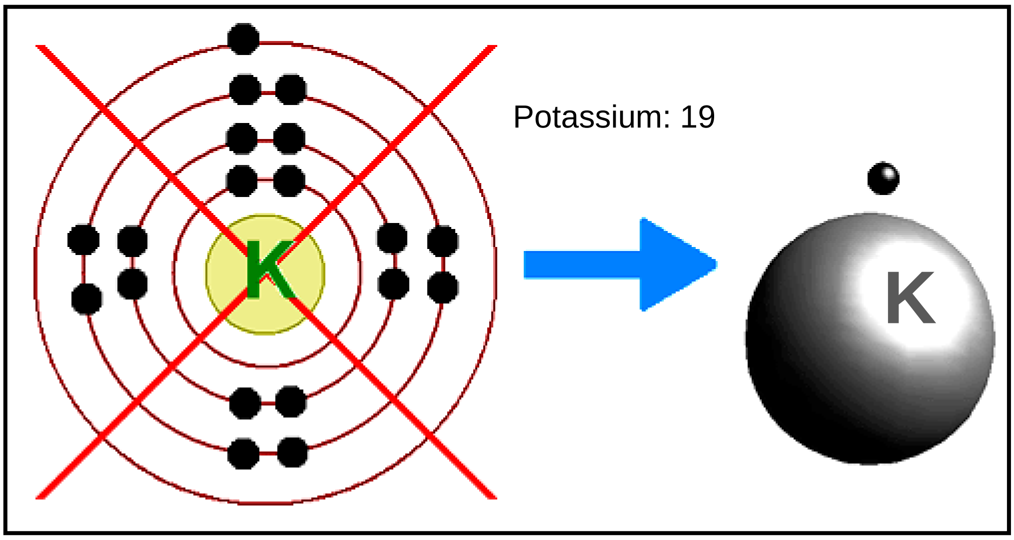
Chlorine: 17 electrons



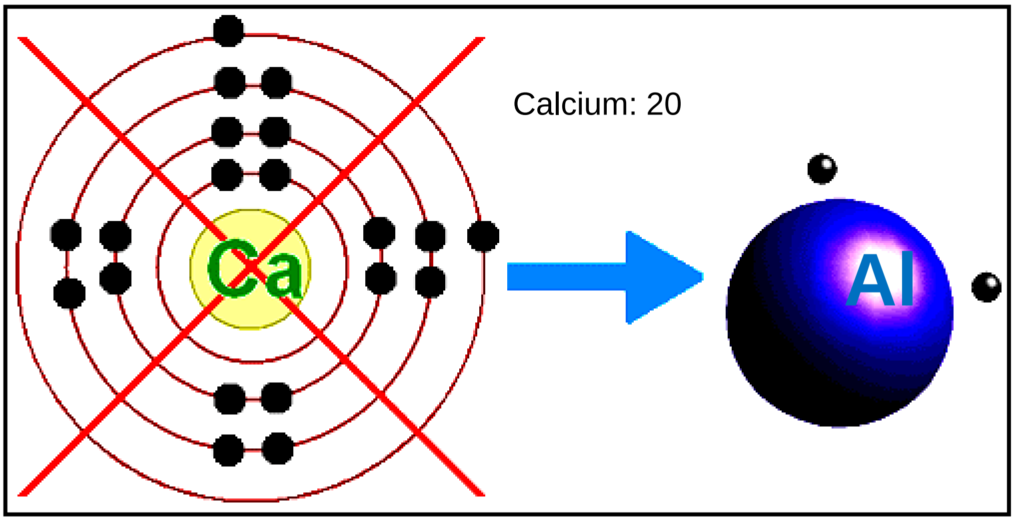
Argon: 18 electrons



Potassium: 19 electrons



Calcium: 20 electrons. Note how the electron dot structure is repeating every eight elements.



Activity: Now test yourself by doing this activity.

Answer all questions according to the given instructions.

Circle the letter of the correct answer.

1. The three basic components of an atom are

   A. protons, neutrons and ions.
   B. protons, neutrinos and ions.
   C. protium, deuterium and tritium.
   D. protons, neutrons and electrons.

2. The nucleus of an atom consists of

   A. neutrons.
   B. electrons.
   C. protons and neutrons.
   D. protons, neutrons and electrons.

3. A single proton has what electrical charge?

   A. Zero charge
   B. Positive charge
   C. Negative charge
   D. Either positive or negative charge

4. Which particles have approximately the same size and mass as each other?

   A. Protons and neutrons
   B. Protons and electrons
   C. Electrons and neutrons
   D. Protons, neutrons and electrons

5. An element is determined by the number of

   A. atoms. B. protons.

   C. neutrons. D. electrons.

6. Which of the following particles would be attracted to each other?

A. Protons and neutrons
B. Protons and electrons
C. Electrons and neutrons
D. Protons, neutrons and electrons

7. An atom is the

A. smallest unit of an element that can exist alone.
B. unit with equal numbers of protons and neutrons.
C. unit with unequal numbers of electrons and protons.
D. smallest particle that participates in chemical bonding.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 2.

Summary

You have come to the end of lesson 2. In this lesson you have learnt that:

- all matter is made up of atoms. Atoms are the basic building blocks of ordinary matter.
- atoms are composed of particles called electrons, protons and neutrons. These particles have different properties.
- in the centre of the atom is the nucleus which is a cluster of protons and neutrons. The nucleus makes up almost all of an atom's mass or weight.
- protons are much larger and heavier than electrons and have a positive charge (+). Neutrons are large and heavy like protons; however neutrons have no electrical charge or they are called electrically neutral (0).
- an extremely powerful force, called nuclear force, holds protons together in the nucleus as they naturally repell one another electrically.
- whirling at fantastic speeds around the nucleus are electrons. Electrons are tiny, very light particles that have a negative electrical charge.
- a particular atom will have the same number of protons and electrons.
- electrons are arranged in shells or orbits around the nucleus. There is a definite arrangement of electrons in these shells and a maximum number of electrons possible in each shell.
- dot diagrams are made for neutral atoms, meaning atoms that have the same number of electrons as protons.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

Practice Exercise 2

Part A. Circle the letter of the correct answer.

1. The atomic number of an atom is the number of

   A. protons.
   B. neutrons.
   C. electrons.
   D. protons and neutrons.

---

2. Of the basic atomic particles, the one that would be attracted to a negatively charged metallic plate is the

   A. protons.
   B. neutrons.
   C. electrons.
   D. protons and electrons.

---

3. The nucleus of the atom is held together by

   A. electrons.
   B. attraction.
   C. magnetism.
   D. nuclear forces.

---

4. Most of the mass of the atom can be found in the

   A. protons.
   B. charges.
   C. nucleus.
   D. electrons.

Part B. Answer the following questions.

1. Describe atom.

   ____
   ____
   ____

2. Describe the sub-atomic particles of atom.

____
____
____
____
____
____

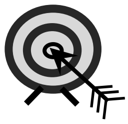
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity:

1. D
2. C
3. B
4. A
5. B
6. B
7. A

Lesson 3: Elements

In lesson 2 you have studied about atom. You have learnt that matter is made up of atoms and that it is the basic building blocks of ordinary matter. You also learnt the different particles of atoms which are electrons, protons and neutrons. These particles have different properties. For this lesson, you will study about elements and its relationship to atoms.

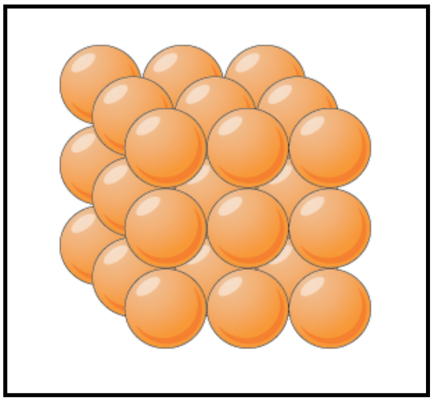


Your Aims:

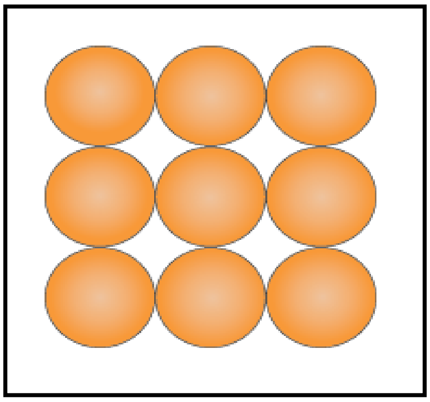
- define element
- identify the characteristics of some elements
- identify the role of some elements in life processes

What are Elements?

Everything is made from atoms, including you. Atoms are tiny particles that are far too small to see, even with a microscope. If people were the same size as atoms, the entire population of the world would fit into a box about a thousandth of a millimetre across. We usually imagine atoms as being like tiny balls, but to make diagrams simpler we often draw atoms as circles.



Atoms drawn as tiny balls



Atoms drawn as circles

There are over a hundred different types of atom, and these are called elements**.**

Elements are substances that cannot be broken down or decomposed into simpler substances. Salt is made up of the elements sodium and chloride. Water is made up of the elements hydrogen and oxygen.

For example, you chop a carrot. If you continue to chop a carrot into smaller and smaller pieces, eventually you would reach a point where you could not cut up the carrot anymore, but still have carrot. You would then have molecules of carrot. The same applies to elements. If you continually cut up a piece of aluminium, you will reach a point that you could no longer divide it. These are aluminium atoms. It is made entirely from one type of atom.

An **atom** is the smallest particle of an element that has the properties of that element. Each element has a special name. For example carbon, oxygen and hydrogen are all elements. Lead and gold are elements too. A piece of pure gold contains only gold atoms. A piece of pure lead contains only lead atoms.

Elements can be present in nature as solids, liquids or gases. The atmosphere is mostly made up of the elements nitrogen (~78%) and oxygen (~21%). The table below shows common elements found in the earth's crust.

oxygen (O)	iron (Fe)	potassium (K)
silicon (Si)	calcium (Ca)	magnesium (Mg)
aluminium (Al)	sodium (Na)	hydrogen (H)

The most common elements found in living things are as follows.

carbon (C)	nitrogen (N)
hydrogen (H)	phosphorus (P)
oxygen (O)	sulphur (S)

The most common elements found in the universe are as follows.

hydrogen (H)	oxygen (O)
helium (He)	carbon (C)

The Role of Elements in Life Processes

Everything around us is composed of chemical elements. These elements have a key function in helping plants and animals live and be healthy. It combines with one another in different proportions to form everything from the air that we breathe, to the wood that we use to build our homes, to our own bodies.

Our bodies use different chemical elements for different functions. As our bodies consume these elements through daily functioning, we have to replace them in order to stay healthy and strong.

The greatest source of these elements is through the food we eat. Because some of us do not always eat the right foods, we sometimes have to take dietary supplements, such as vitamins, to assure that we maintain the proper chemical balance in our bodies.

Some of the major elements that our bodies use to function properly are described in the following paragraphs.

Calcium (Ca)
Most of us know that calcium is important in building and maintaining strong bones and teeth, but it is also important for many other things. It helps control things like muscle growth and the electrical impulses in your brain.


Calcium

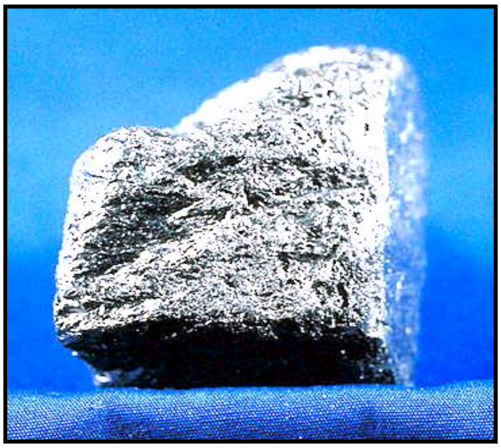
This vital element is also necessary to maintain proper blood pressure and make blood clot when cut your skin. Calcium also enables other molecules to digest food and make energy for the body. Increasing calcium intake in our diet is believed to lower high blood pressure and prevent heart disease. It is also used to treat arthritis, leg cramps, muscle spasms and colon cancer.

Carbon (C)
The element carbon is perhaps the single most important element to life. Virtually every part of our bodies is made up with large amounts of this element. The carbon atom can be thought of as a basic building block. These building blocks can be attached to each other to form long chains, or they can be attached to other elements. This is the reason why we are known as "carbon based life forms". Without carbon, our bodies would just be a big pile of loose atoms without a framework to be built into a person.

Chlorine (Cl)
Anyone who has swallowed a mouthful of water at a swimming pool would probably tell you that chlorine is one of the most unpleasant elements they have ever swallowed and never swallow chlorine ever again.

This element, however, is essential for humans to live - we would die without it. Chlorine is found throughout the body; in the blood, in the fluid inside cells and in between cells.

Chlorine carries an electrical charge when dissolved in body fluids. The electrical charge that these elements carry is what allows nerve cells to work. It also helps muscles flex and relax normally. Chlorine is also extremely important in allowing us to digest our food properly and to absorb many other elements that we need to survive.



Carbon

Chlorine liquid

Copper (Cu)
Copper is an element that is very important for good health. It is a major component of the oxygen carrying part of blood cells. It also helps protect our cells from being damaged by certain chemicals in our bodies.

Copper

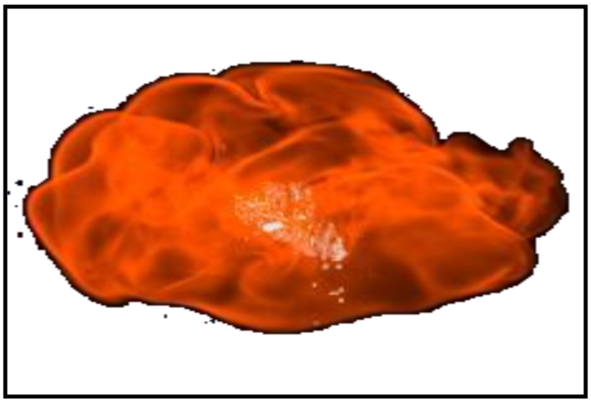
Copper, along with vitamin C, is important for keeping blood vessels and skin elastic and flexible. This important element is also required by the brain to form chemicals that keep us awake and alert. Copper also helps your body produce chemicals that regulate blood pressure, pulse, and healing.

Fluorine (F)
Fluorine is an element that the body uses to strengthen bones and teeth. This element differs from other elements that the body needs because we get most of it from the water we drink, not from the food that we eat.

The form of fluorine that exists in nature, fluoride, is added to most drinking water supplies. It is also added to toothpaste for its ability to fight cavities.

Fluoride, along with large quantities of calcium, is a large part of what makes your bones strong. When the body does not receive enough fluoride, bones start to loose calcium, and then become weak and brittle.

Fluorine



Exploding hydrogen bubble

Hydrogen (H)
Hydrogen is extremely important in allowing us to digest our food properly and to absorb many other elements that we need to survive. Water is a **compound*** of hydrogen and oxygen (H_2O). Hydrogen is a critical component of water and minute chemical bonds called "hydrogen bonds" give water many of its unique properties.

We can survive weeks without food, but we would die after only a few days without water. It dissolves other life-supporting substances and transports them to fluids in and around our body.

Also, hydrogen is practically always bound to the carbon that our bodies are constructed of. Without this arrangement, our bodies would be a pile of atoms on the ground.

Iodine (I)
Iodine is an element that is required in very small amounts by the human body. Iodine is found in a purple solution that we put on scrapes and cuts to help our wounds heal faster by preventing them from getting infected.

But the most important thing about iodine is that it keeps our thyroid gland, located in the base of your neck, healthy.

Iodine vapour

The thyroid gland uses iodine to make chemicals that affect our growth, the way we development and how we burn the energy that we get from the food we eat. If we do not get enough iodine in our diets, we can expect to have a loss of energy and to gain weight.

Iron (Fe)
The element iron has many functions in the body. This element is used by the body to make tendons and ligaments.

Certain chemicals in our brain are controlled by the presence or absence of iron. It is also important for maintaining a healthy immune system and for digesting certain things in the food that we eat.

In fact, iron plays an important part of how our body obtains energy from our food. The iron we obtain from our diet is an essential part of haemoglobin - the part of our blood that carries oxygen. Iron is essential for blood to work efficiently.

Pure iron

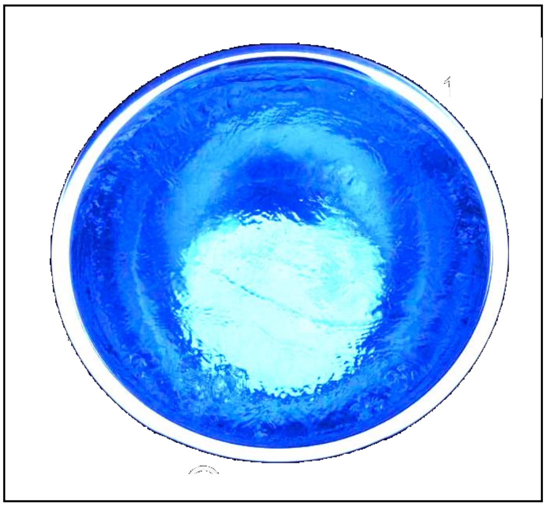
Liquid nitrogen

Nitrogen (N)
Nitrogen is another important element. It plays an important role in digestion of food and growth. As you may know, almost 80% of the air we breathe is made up of nitrogen. But humans cannot use the nitrogen in the air we breathe, that nitrogen is in the wrong form. We have to get nitrogen, in a different form, from the food that we eat.

Fortunately, there is plenty of nitrogen in food to nourish our bodies. Nitrogen is found in large amounts in all kinds of food. Spaghetti, salads, breakfast cereal, hamburgers and even cookies have lots of nitrogen in the form that our bodies need. When your body digests this food and makes it into energy, the first step is to remove nitrogen atoms from the molecules in the food. While your body is busy digesting the rest of this food and making it into energy, these nitrogen atoms are already being used to help you grow.

Oxygen (O)

It may obvious that people need to breathe oxygen to survive, but plants need this element too. Without oxygen, plants cannot survive. Without plants, we would not have food to eat. Water is a compound of hydrogen and oxygen (H_2O) and it is necessary for all life. In fact, more than 50% of our bodies are made of water. It dissolves other life-supporting substances and transports them to fluids in and around our cells. Many people consider water to be the "blood of life".



Liquid oxygen

Potassium (K)

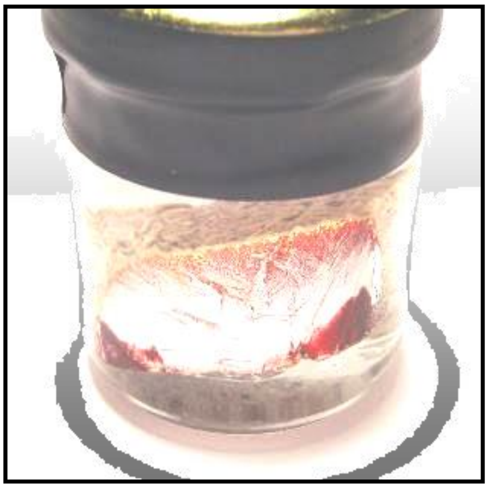
Our bodies are made up of millions of tiny cells, such as brain cells, skin cells, liver cells. These cells make up the different organs in our bodies, such as the brain, skin, or liver. Potassium is extremely important to cells, and we need it to survive.

Cells are the small building blocks of the human body. In order to work properly, cells need to let things enter and leave them. But it is not just nerve cells that depend on potassium. Most of our cells depend on it. Every time you flex your muscles, blink your eyes, yawn, eat lunch, or do anything, you are using potassium. This element is indeed a very important element in our bodies.

Sodium (Na)

Sodium is an element that is vital to human life. Together with potassium and chlorine, it forms a very important part of blood plasma. Without sodium, our cells could not get the nutrients they need to survive. Sodium also allows our bodies to maintain the right blood chemistry and correct amount of water in our blood. This element also allows our muscles to contract normally. Furthermore, our bodies need sodium to digest the food that we eat. Normal functioning of our nervous system also depends on this important element.

Sodium



Potassium

Sulphur (S)

Sulphur is an important element that is used in small amounts to help construct all parts of the human body. It helps protect cells in our bodies from environmental hazards such as air pollution and radiation.

Sulphur

It also slows the aging process, keeps your skin supple and elastic and extends our life span. It helps our liver function properly, helps us digest the food that we eat and then turn that food into energy. Sulphur is also important for helping our blood clot when we cut our skin or bruise ourselves.

Characteristics of some elements

At the beginning of the twenty-first century, there were 114 known elements, ranging from hydrogen (H), whose atoms have only one electron, to the as-yet unnamed element whose atoms contain 114 electrons. New elements are difficult to produce. Only a few atoms can be made at a time, and it usually takes years before scientists agree on who discovered what and when. The table below gives you characteristics of some elements.

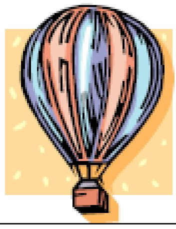
Element	Symbol	Characteristics
Aluminium	Al	A lightweight, silvery metal.
Calcium	Ca	Common in minerals, seashells, and bones.
Carbon	C	Basic in all living things.
Chlorine	Cl	A toxic gas.
Copper	Cu	The only red metal.
Gold	Au	The only yellow metal.
Helium	He	A very light gas.
Hydrogen	H	The lightest of all elements; a gas.
Iodine	I	A non-metal; used as antiseptic.
Iron	Fe	A magnetic metal; used in steel.
Lead	Pb	A soft, heavy metal.
Magnesium	Mg	A very light metal.
Mercury	Hg	A liquid metal; one of the two liquid element.
Nickel	Ni	A non- corroding metal; used in coins.
Nitrogen	N	A gas; the major component of air.
Oxygen	O	A gas; the second major component of air.

Phosphorus	P	A non-metal; essential to plants.
Potassium	K	A metal; essential to plants; commonly called "potash".
Silicon	Si	A semiconductor; used in electronics.
Silver	Ag	A very shiny, valuable metal.
Sodium	Na	A soft metal; reacts readily with water, air.
Sulphur	S	A yellow non-metal; flammable.
Titanium	Ti	A light, strong, no corroding metal used in space vehicles.
Uranium	U	A very heavy metal; fuel for nuclear power.

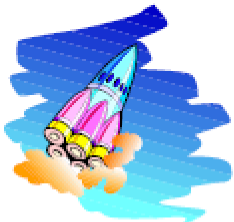
Activity: **Now test yourself by doing this activity.**

A. Choose from the box the element that associates with the pictures.

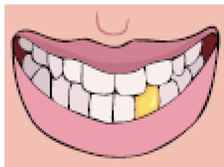
Aluminium	Gold	Iron
Carbon	Helium	Oxygen
Chlorine	Hydrogen	Uranium



1.



2.



3.

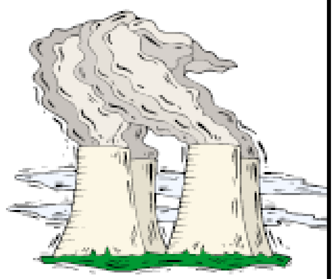
4.

5.

6.

7.

8.



9.

B. Fill in the blanks with words from the box.

chains	elements	hydrogen
carbon	carbon dioxide	

Carbon is one of the most important __________ on earth. All living creatures have __________ in their bodies. Carbon gets together with other elements and can build long __________. Carbon and __________are examples in petroleum and gas. __________ is in the air that we breathe out.

C. Circle the letter of the correct answer.

1. C is the chemical symbol for which element?

A. Carbon B. Copper

C. Calcium D. Caesium

2. **At** is the chemical symbol for which element?

A. Silver B. Arsenic

C. Astatine D. Actinium

3. **W** is the chemical symbol for which element?

A. Tin B. Silver

C. Mercury D. Tungsten

4. **Ar** is the chemical symbol for which element?

A. Argon B. Arsenic

C. Astatine D. Americium

5. **Hg** is the chemical symbol for which element?

A. Argon B. Mercury

C. Astatine D. Tungsten

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 3.

Summary

You have come to the end of lesson 3. In this lesson you have learnt that:

- elements are substances that cannot be broken down or decomposed into simpler substances.
- elements can be present in nature as solids, liquids or gases. The atmosphere is mostly made up of the elements nitrogen (~78%) and oxygen (~21%).
- calcium is important in building and maintaining strong bones and teeth, helps control muscle growth and electrical impulses in the brain, maintain proper blood pressure and make blood clot when you cut your skin..
- carbon is the basic building block of our body. These building blocks can be attached to each other to form long chains, or they can be attached to other elements.
- chlorine carries an electrical charge and when dissolved in body fluids, allows nerve cells to work. It also helps muscles flex and relax normally.
- copper is a major component of the oxygen carrying part of blood cells. It also helps protect our cells from being damaged by certain chemicals in our bodies.
- fluorine is an element that the body uses to strengthen bones and teeth.
- hydrogen helps to digest our food properly and to absorb many other elements that we need to survive.
- iodine help our wounds heal faster by preventing them from getting infected. It also keeps our thyroid gland healthy.
- the element iron is used by the body to make tendons and ligaments.
- nitrogen plays an important role in digestion of food and growth.
- people need to breathe oxygen to survive, but plants need this element too. Without oxygen, plants could not survive. Without plants, animals will not survive and we would not have food to eat.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Answer the following questions:

1. Define element.

____

____

---

2. Identify the characteristics of aluminium, calcium, carbon, chlorine, copper, gold hydrogen and iron.

Aluminium	
Calcium	
Carbon	
Chlorine	
Copper	
Gold	
Hydrogen	
Iron	

---

3. Identify the role of calcium, copper, chlorine, hydrogen, iodine and carbon in our body.

A. Calcium

____

B. Copper

____

C. Chlorine

____

D. Hydrogen

____

E. Iodine

____

F. Carbon

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity

Part A.

1. Helium
2. Hydrogen
3. Gold
4. Carbon
5. Iron
6. Aluminium
7. Chlorine
8. Oxygen
9. Uranium

Part B.

1. elements
2. creatures
3. chains
4. hydrogen
5. carbon dioxide

Part C

1. A
2. C
3. D
4. B
5. B

Lesson 4: Compounds

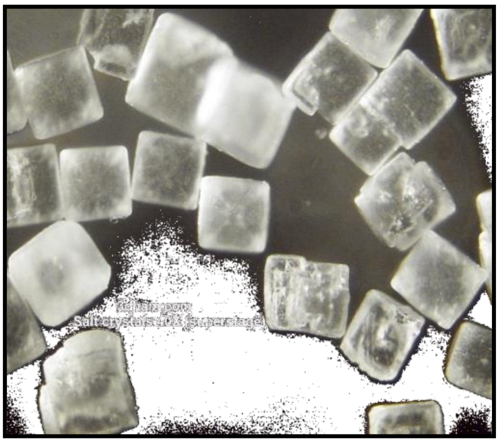
From the previous lesson, you have studied about elements. You have learnt the connection between elements and atoms. You also studied the different role of elements in life processes and some of its characteristics. For this lesson you will study about compounds.

Your Aims:

- define compounds
- identify the uses of some compounds
- compare the characteristics of elements and compounds

Compounds

A compound is a substance formed when two or more elements are chemically joined. There are millions of different compounds around you.



Salt crystals

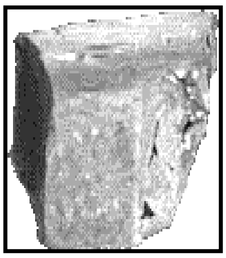
Everything you can see is one type of compound or another. Water, salt, and sugar are examples of compounds. When elements join and become compounds, they lose their individual traits. Sodium alone is very reactive.

But when sodium and chlorine combine, they form a non-reactive substance called sodium chloride (Salt, NaCl). The compound has none of the traits or the original elements. The new compound is not as reactive as the original elements. It has a new life of its own.

A **chemical formula** is used as quick way to show the composition of compounds. Letters, numbers, and symbols are used to represent elements and the number of elements in each compound.

Let us look at the illustration of sodium chloride as an example.

Sodium (Na)



Chlorine (Cl_2)

Sodium chloride ($NaCl_2$)

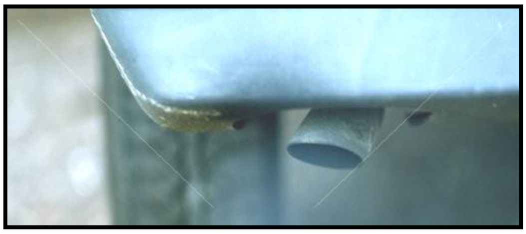
Here are other examples:

Element	**Element**	**Compound**
Carbon (C) A black solid.	Oxygen (O_2) A gas needed for burning.	Carbon dioxide (CO_2) A colourless gas can be used to put out fires.
Sodium (Na) A shiny very reactive metal that explodes in water.	Chlorine (Cl2) A green highly poisonous gas.	Sodium Chloride (NaCl) A white harmless compound that we use to flavour food.
Element	**Element**	**Compound**
Hydrogen (H_2) An explosive gas.	Oxygen (O_2) A gas needed for burning.	Water (H_2O) A liquid we drink and can be used to put out fires.
Iron (Fe) A metallic grey solid easily attracted to a magnet.	Sulphur (S) A bright yellow solid.	Iron Sulphide (FeS) A stoned like grey solid with no magnetic properties.

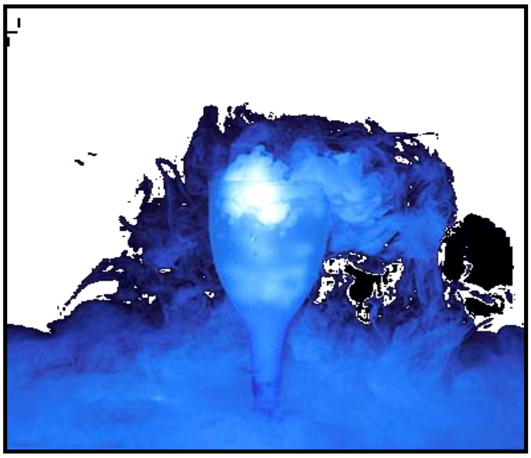
Uses of some compounds

Carbon dioxide (CO_2)

Carbon dioxide, chemical compound, CO_2, a colourless, odourless, tasteless gas that is about one and one-half times as dense as air under ordinary conditions of temperature and pressure.


Carbon dioxide gas from car

It does not burn, and under normal conditions it is stable, inert and non-toxic. It will however support combustion of magnesium to give magnesium oxide and carbon. Although it is not a poison, it can cause death by suffocation if inhaled in large amounts.


Dry ice

Its greatest use as a chemical is in the production of carbonated beverages. Formed by the action of yeast or baking powder, carbon dioxide causes the rising of bread dough.

The compound is also used in water softening, in the manufacture of aspirin and lead paint pigments. It also has numerous non-chemical uses.

It is used as a pressurising medium and propellant. Examples are in aerosol cans of food, fire extinguishers, target pistols, and for inflating life rafts. Because it is relatively inert, it is used to provide a non-reactive atmosphere. For example, it is used for packaging foods, such as coffee, that can be spoiled by oxidation during storage. Solid carbon dioxide, known as dry ice, is used as a refrigerating agent.

Sugar crystals

Sugar

When using sugar (sucrose)($C_{12}H_{22}O_{11}$) most people think of it only as a sweetener. For example, adding a teaspoon to your coffee or sprinkling a little over strawberries.

But when sugar is used in baking, its role becomes more complex as it also adds volume, tenderness, texture, colour, and acts as a preservative.

The ability of sugar to hold moisture also prolongs the shelf life of baked goods. Liquid sugars hold more moisture than other types of sugars. Just as brown sugar will hold more moisture than granulated white sugar.

Sodium hydroxide (NaOH)

It is available in the form of a crystalline substance that is odourless and white in colour.

Sodium hydroxide pellets

Sodium hydroxide (NaOH) is also named as caustic soda, lye and sodium hydrate. It is also available in the form of a solution in water with different concentrations.

Various food preparing procedures involve use of sodium hydroxide for chemical peeling of fruits and vegetables.

It is also used for cleaning drains that are clogged, cleansing agent used as cleaners for oven, for degreasing glass and stainless bake ware, as an agent for straightening and relaxing hair and in manufacturing procedures of paper and soaps. In the production of bio-diesel, it works as a catalyst.

Ammonia

Ammonia

Ammonia (NH_3) can take the form of a strong smelling liquid or gas. Even in low concentrations, inhaling ammonia or getting the solution on your skin can cause burning, fainting, or death.

The largest use of ammonia is in fertilizers, which help provide increased yields of crops such as corn, wheat, and soybeans. Liquid ammonia, ammonia water solutions are all used as sources of soluble nitrogen. Nitric acid results from oxidation of ammonia in the presence of a platinum catalyst. Nitric acid and nitrates are needed for the manufacture of explosives like TNT, nitroglycerin, gunpowder, and also for propellants in cartridges for rifles and machine guns.

The pulp and paper industry uses ammonia for pulping wood and as case in dispersant in the coating of paper. The food and beverage industry uses ammonia as a source of nitrogen needed for yeast and micro-organisms.

Ammonia NH_3) is used by the leather industry as a curing agent, as a slime and mold preventative in tanning liquors and as a protective agent for leathers and furs in storage. Weak ammonia solutions are also widely used as commercial and household cleaners and detergents.

Water (H_2O)

Water is a tasteless, odourless, and nearly colourless substance in its pure form that is essential to all known forms of life and the most universal solvent. Water is an abundant substance on Earth. It exists in many places and forms. It appears mostly in oceans and polar ice caps, but also as clouds, rain water, rivers, and sea ice.

On the planet, water is continuously moving through the cycle. This natural resource is becoming scarcer in certain places as human population in those places increases, and its availability is a major social and economic concern. Even though there always has been plenty of fresh water on Earth, water has not always been available when and where it is needed, nor is it always of suitable quality for all uses.

Water fit for human consumption is called potable water. It is used in the home every day, including water for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens.

Water in the sea

What are the properties of compounds?

1. A compound cannot be separated into its constituents by mechanical or physical means.

   For example, if we bring a magnet near a sample of iron sulphide, the iron present in the iron sulphide cannot be separated.

2. Properties of the compound differ entirely from those of its constituent elements. For example, water is made up of hydrogen and oxygen. However, the properties of hydrogen and oxygen (both gases) are different from water (liquid). Hydrogen is combustible; oxygen is a supporter of combustion whereas water (made up of both hydrogen and oxygen) puts out a flame.

3. Energy changes are involved in the formation of a compound. For example, iron and sulphur reacts only when heat is supplied.

4. The elements in a compound are in a fixed proportion by weight.

5. A compound is a homogeneous substance. That is it is the same throughout in properties and composition.

6. A compound has a fixed melting and boiling point. For example, ice melts at $0^{O}C$.

What are the properties of elements?
Element is defined as a substance that cannot be further reduced to simpler substances by ordinary processes. It is made up of atoms of only one kind. It is divided into metals and **non-metals***.

The properties of metals
1. They are strong under tension and compression. That means they can withstand crushing and stretching without breaking.
2. They are malleable. That means they can be hammered and bent into different shapes without breaking.
3. They are ductile. That means they can be drawn out to make wires.
4. They are sonorous. That means they can make a ringing noise when you strike them.
5. They are shiny when polished.
6. They are good conductors of heat and electricity.
7. They have high melting and boiling point. They are all solid at room temperature except mercury.
8. They have high densities. That means they feel heavy.

The properties of non-metals
1. They are not strong, malleable, ductile or sonorous. In fact when solid non-metals are hammered, they break up- they are brittle.
2. They have lower melting and boiling points than metals. One of them is a liquid and eleven are gases at room temperature.
3. They are poor conductors of heat and electricity. Graphite is the only exception.
4. They have low densities.

Activity: **Now test yourself by doing this activity.**

Circle the letter of the correct answer.

1. The fact that Iron cannot be changed into a simpler form tells you that Iron is a/an __________.

   A. mixture B. molecule

   C. element D. compound

2. What is the meaning of the chemical equation below?

   $$2H_2 + O_2 \longrightarrow 2H_2O$$

   A. Water combines with oxygen.
   B. Hydrogen and oxygen are made.
   C. Hydrogen combines with oxygen to form water.
   D. A compound is breaking into the elements that make it.

3. Which is **not** an element?

   A. Oxygen
   B. Nitrogen
   C. Hydrogen
   D. Carbon dioxide

4. Which can be separated into simpler substances by a chemical change only?

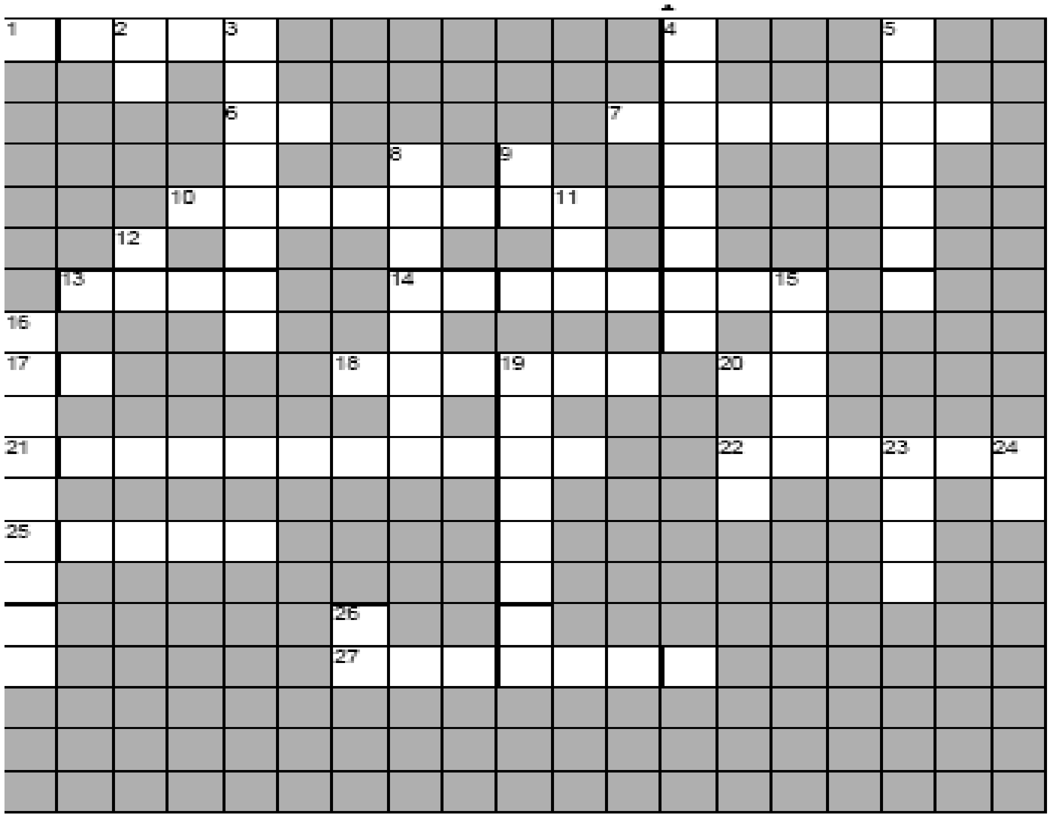
   A. A solid. B. A mixture.

   C. An element. D. A compound.

5. The chemical symbols of chlorine, potassium, copper, sodium, nitrogen and iron in order are

   A. Cl, P, Co, So, Ni, I
   B. Cl, K, Co, So, N, Fe
   C. Cl, K, Cu, Na, N, Fe
   D. Cl, P, Cu, Na, Ni, Fe

Part B. Answer this crossword puzzle



Across

1. Type of compound where electrons are gained or lost.[5]
6. Symbol of magnesium.[2]
7. A radioactive metal.[7]
10. Type of compound where electrons are shared between bonded atoms.[8]
13. Noble or inert gas used in street signs.[4]
14. Common salt is sodium ____.[8]
17. Symbol of gold.[2]
18. Positively charged particle of an atom.[6]
20. Symbol of mercury.[2]
21. Ion containing atoms of hydrogen, carbon and oxygen.[11]
22. Number of protons in an atom is its ____ number.[6]
25. Inert gases are called ____ gases.[5]
27. Pure substance containing one type of atom.[7]

Down

2. Symbol of sodium.[2]
3. Pure substance with different types of atoms.[8]
4. ____ Table of Elements.[8]
5. Particle with no charge in nucleus of atom.[7]
8. Negatively charged particle of an atom.[8]
9. Symbol of zinc.[2]
11. Maximum number of electrons in first electron level.[3]
12. Symbol of helium.[2]
15. Maximum number of electrons in second electron level.[5]
16. Cement is calcium ____.[9]
19. Ti is the symbol for this metal.[8]
22. Symbol of silver.[2]
23. Number of protons and neutrons in an atom is its ____ number.[4]
24. Symbol of chlorine.[2]
26. Symbol of iron.[2]

CHECK YOUR WORK.ANSWERS ARE AT THE END OF LESSON 4.

Summary

You have come to the end of lesson 4. In this lesson you have learnt that:

- a compound is a substance formed when two or more elements are chemically joined.
- carbon dioxide's greatest use as a chemical is in the production of carbonated beverages. Formed by the action of yeast or baking powder, carbon dioxide causes the rising of bread dough.
- sugar is used in baking. Its role becomes more complex as it also adds volume, tenderness, texture, colour, and acts as a preservative.
- sodium hydroxide is also used for cleaning drains that are clogged, cleansing agent used as cleaners for oven, for degreasing the glass and stainless bake ware, as an agent for straightening and relaxing hair and in the manufacturing procedures of paper and soaps. In the production of bio-diesel, it works as a catalyst.
- the largest use of ammonia is in fertilizers for pulping wood, as a source of nitrogen needed for yeast and micro-organisms, as slime and mould preventative in tanning liquors and commercial and household cleaners and detergents.
- water is used in the home every day, including water for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

Answer the following questions:

1. Define compound.

____

____

2. Give the uses of

   A. Carbon dioxide

   ____

   ____

   B. Water

   ____

   ____

   ____

   C. Sodium hydroxide

   ____

   ____

3. Compare the characteristics of elements and compounds.

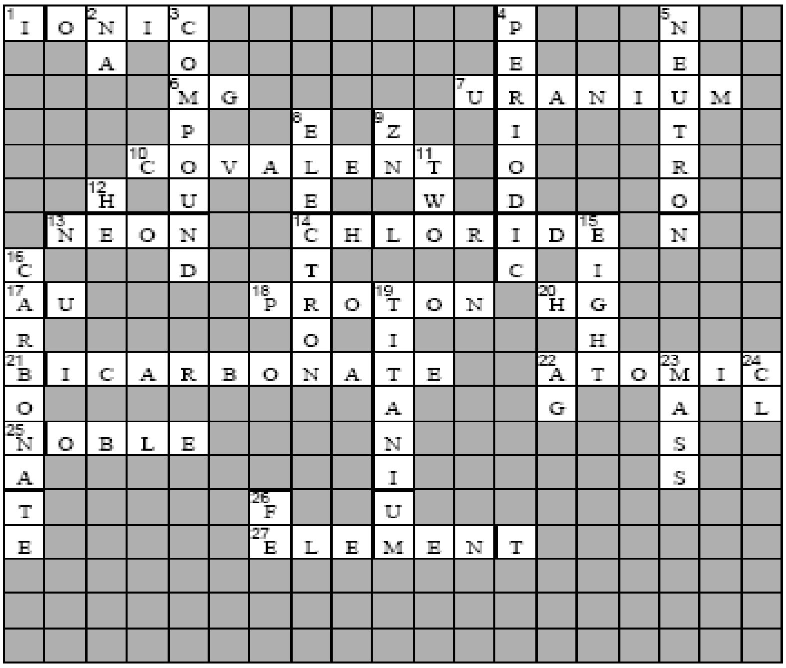
Element	Compound
Characteristics of metals ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ Characteristics of non-metals ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________	______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity

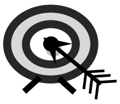
1. C
2. C
3. D
4. D
5. C

Part B. Crossword puzzle



Lesson 5: Mixtures

From the previous lesson, you have studied about compounds. You have learnt the different uses of compounds. You also studied the different characteristics of elements and compounds and you compared them. For this lesson you will study about mixtures.



Your Aims:

- define mixture, solute, suspension, homogeneous and heterogeneous
- identify the types and properties of mixtures

What is a Mixture?

Mixtures are two or more substances that are mixed together but not chemically joined.

A good example of a mixture is a salad. There are tomatoes, lettuce, cucumbers, and salad dressing all mixed together. No chemical reactions occur between the vegetables and dressing. You can separate each of the vegetables from each other.

Vegetable salad mixture

Homogeneous and Heterogeneous Mixtures

The prefixes "homo"- indicate sameness. A **homogeneous mixture** has the same uniform appearance and composition throughout.

Many homogeneous mixtures are commonly referred to as **solutions***. Particle size distinguishes homogeneous solutions from other heterogeneous mixtures. Solutions have particles which are the size of atoms or molecules - too small to be seen.

Foggy Mountain

A **colloid*** is a homogeneous solution with intermediate particle size between a solution and a **suspension***. Colloid particles may be seen in a beam of light such as dust in air in a "shaft" of sunlight. Milk, fog, and jelly are examples of colloids.

Corn oil is homogeneous. White vinegar is homogeneous. A sugar solution is homogeneous since only a colourless liquid is observed. Air with no clouds is homogeneous.The prefixes: "hetero"- indicate difference.

A **heterogeneous mixture** consists of visibly different substances or phases. The three phases or states of matter are gas, liquid, and solid.

In contrast a **suspension** is a heterogeneous mixture of larger particles. These particles are visible to the naked eye and will settle out on standing. Examples of suspensions are: fine sand or silt in water or tomato juice.

For example, beach sand is heterogeneous since you can see different coloured particles. Vinegar and oil salad dressing is heterogeneous since two liquid layers are present, as well as solids. Air with clouds is heterogeneous, as the clouds contain tiny droplets of liquid water.


Vinegar and oil mixture


Tomato juice is a suspension

Solutions are homogeneous mixtures.
A **solution** is a mixture of two or more substances in a single phase. At least two substances must be mixed in order to have a solution. The substance in the smallest amount and the one that dissolves or disperses is called the **solute**. The substance in the larger amount is called the **solvent**. In most common instances, water is the solvent.


Different solutions in the laboratory


Salt solution in an aquarium

The gases, liquids, or solids dissolved in water are the solutes. Some common solutions include ammonia and vinegar as well as salt water. The amount of the solutes compared to the solvent in a solution is the concentration of the solution. The greatest concentration of a solute in a solvent is the solubility of a solution. When the solvent contains the most solute it can hold, it is said to be saturated; if it has less solute than it can hold, it is unsaturated.

1. A mixture may be homogeneous or heterogeneous. A homogeneous mixture has a uniform composition throughout its mass. For example, sugar or salt dissolved in water and alcohol in water.A heterogeneous mixture does not have a uniform composition throughout its mass. There are visible sharp boundaries. For example, oil and water, salt and sand.
   .
2. The constituents of a mixture can be separated by physical means like filtration, evaporation, sublimation and magnetic separation.
3. In the preparation of a mixture, energy is neither evolved nor absorbed.
4. A mixture has no definite melting and boiling points.
5. The constituents of a mixture retain their original set of properties. For example, a magnet attracts iron fillings.

Types of mixtures

Matter	**Mixture type**	**Example**
Solid	Solid mixture	Iron fillings and sulphur
Solid	Liquid mixture	Common salt and water
Solid	Gas mixture	Air trapped in soil
Liquid	Gas mixture	Oxygen dissolved in water
Liquid	Liquid mixture	Water and alcohol
Gas	Gas mixture	Air containing hydrogen, oxygen, nitrogen, carbon dioxide.

Look at the **differences** between mixtures and compounds at the table below.

Mixtures	**Compounds**
A mixture can be separated into its constituents by physical processes (filtration, evaporation, sublimation, distillation).	A compound cannot be separated into its constituents by physical processes. It can be separated by chemical means.
A mixture shows the properties of its constituents.	A compound has a new set of properties different from its constituents.

Mixtures	Compounds
Composition of a mixture varies and the constituents are present in any proportion by weight. It does not have a definite formula.	The composition of a compound is fixed and the constituents are present in fixed proportions by weight. It has a definite formula.
The constituents do not react chemically, thus no energy changes take place.	Chemical reactions take place and energy changes in the form of heat and light are involved.
A mixture does not have a fixed melting point and boiling point Examples, are air, sand and salt.	A compound has a fixed melting point and boiling point Examples are water (H_2O), iron sulphide(FeS).

Activity: **Now test yourself by doing this activity.**

Circle the letter of the correct answer.

1. A combination of substances, not in fixed amounts, that can be easily separated is a __________.

   A. atom B. mixture

   C. element D. compound

2. This is a mixture of two or more substances in which one or more of these substances (solutes) are dissolved in another substance.

   A. Solution B. Molecule

   C. Element D. Compound

3. The amount of the solutes compared to the solvent in a solution is the__________ of the solution.

   A. density B. reaction

   C. composition D. concentration

4. This is similar to a solution, but the particles that are in it are able to be seen by the naked eye.

A. Catalyst B. Colloid

C. Compound D. Suspension

5. This is a type of mixture in which one substance is split up into tiny particles and spread throughout another substance.

A. Solute B. Colloid

C. Solubility D. Suspension

6. Salt and water is an example of a __________.

A. solution B. emulsion

C. suspension D. colloid

7. A mixture of clay and water is an example of a __________.

A. solution B. emulsion

C. suspension D. colloid

8. Oil and water is an example of a __________ mixture.

A. solution B. homogeneous

C. suspension D. heterogeneous

9. A mixture of alcohol and water is an example of a __________.

A. solution B. emulsion

C. suspension D. colloid

10. Which of these is an example of a colloid mixture?

A. Soil and water
B. Salt and water
C. Oil and vinegar
D. Liquid laundry starch and water

11. If you want to make a solution, which would you mix with water?

A. Oil B. Sand

C. Water D. Alcohol

12. A mixture is described as looking homogeneous, not settling when left standing undisturbed. This mixture would be classified as a __________.

A. solution B. emulsion

C. suspension D. colloid

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 5.

Summary

You have come to the end of lesson 5. In this lesson you have learnt that:

- mixtures are two or more substances that are mixed together but not chemically joined.
- a homogeneous mixture has the same uniform appearance and composition throughout.
- a colloid is a homogeneous solution with intermediate particle size between a solution and a suspension.
- a heterogeneous mixture consists of visibly different substances or phases.
- suspension is a heterogeneous mixture of larger particles. These particles are visible to the naked eye and will settle out on standing.
- the substance in the smallest amount and the one that dissolves or disperses is called the solute. The substance in the larger amount is called the solvent.
- the greatest concentration of a solute in a solvent is the solubility of a solution. When the solvent contains the most solute it can hold, it is said to be saturated; if it has less solute than it can hold, it is unsaturated.
- the constituents of a mixture can be separated by physical means like filtration, evaporation, sublimation and magnetic separation.
- in the preparation of a mixture, energy is neither evolved nor absorbed.
- a mixture has no definite melting and boiling points.
- the constituents of a mixture retain their original set of properties.
- in a solid matter, the types of mixtures are solid, liquid and gas.
- in a liquid matter, the types of mixtures are liquid and gas.
- in a gas matter, the type of mixture is only gas.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions:

1. Define the following.

   a. Mixtures

   ____

   ____

   b. Homogeneous mixture

   ____

   ____

   c. Heterogeneous mixture

   ____

   ____

   d. Suspension

   ____

   ____

   e. Solute

   ____

   ____

2. Fill in the table below.

Matter	Mixture type	Example
Solid		
Solid		
Solid		
Liquid		
Liquid		
Gas		

3. Identify the properties of a mixture.

   a. ______________________________

   ____

   b. ______________________________

   ____

c. ____
____

d. ____
____

e. ____
____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity

1. B
2. A
3. D
4. D
5. B
6. A
7. C
8. D
9. A
10. D
11. D
12. D

Answers to Practice Exercises 1 - 5

Practice Exercise 1

1. a. A solid has a certain size and shape. You can change the shape of solid.
   b. Liquid matter has a size and volume. Volume means it takes up space but does not have a definite shape. It takes the shape of the container. Liquids can flow, be poured and spilled.
   c. A gas is matter that has no shape or size of its own. It is invisible. Gases have no colour and it is all around you.

2. All substances have properties that we can use to identify or describe them. For example we can identify a person by their face, their voice, height, finger prints, and DNA. There are two basic types of properties that we can associate with matter. These properties are called physical properties and chemical properties.

   Physical properties do not change the chemical nature of matter. Physical properties are readily observable like colour, size, lustre, freezing point, boiling point, melting point, attraction or repulsion to magnets, density or smell. Chemical properties are only observable during a chemical reaction. Examples are heat of combustion, reactivity with water and pH.

3. Physical change does not produce a new substance. If you melt a block of ice, you still have water (H_2O) at the end of the change. If you break a bottle, you still have glass. Painting a piece of wood will not make it stop being wood. Some common examples of physical changes are melting, freezing, condensing, subliming, vaporising, breaking, crushing, cutting and bending. In all of these changes, you can get the original materials back.

   A chemical change or chemical reaction produces a new substance. The new substance is different from the original. It has properties that are different than those of the starting materials. Plus, you cannot get the original materials back easily. Examples of chemical changes include combustion (burning), digestion, respiration, photosynthesis, decomposition, cooking an egg, rusting of an iron pan and mixing hydrochloric acid and sodium hydroxide to make salt and water.

4. Signs of chemical change are colour change, gain or release of energy, odour changes and production of gases or solids and not easily reversed.

Practice Exercise 2

Part A.

Circle the letter of the correct answer.

1. **A.** 2. **A.** 3. **D.** 4. **C.**

Part B.

1. Atoms are the basic building blocks of ordinary matter. Atoms can join together to form molecules, which in turn form most of the objects around you. An atom is like a tiny solar system. In the centre of the atom is the nucleus which is a cluster of protons and neutrons. The protons have a positive electric charge while the neutrons are electrically neutral. The nucleus makes up almost all of an atom's mass or weight. Whirling at fantastic speeds around the nucleus are smaller and lighter particles called electrons which have a negative electric charge.

2. Atoms are composed of particles called electrons, protons and neutrons.These particles have different properties. Electrons are tiny, very light particles that have a negative electrical charge. Protons are much larger and heavier than electrons and have the opposite charge, protons have a positive charge. Neutrons are large and heavy like protons; however neutrons have no electrical charge. Each atom is made up of a combination of these particles. The protons and neutrons cluster together in the central part of the atom, called the nucleus.

Practice Exercise 3

1. Elements are substances that cannot be broken down or decomposed into simpler substances.
2.

Aluminium	A lightweight, silvery metal.
Calcium	Common in minerals, seashells, and bones
Carbon	Basic in all living things.
Chlorine	A toxic gas.
Copper	The only red metal.
Gold	The only yellow metal.
Hydrogen	The lightest of all elements; a gas.
Iron	A magnetic metal; used in steel.

3. A. Calcium is important in building and maintaining strong bones and teeth, helps control muscle growth and the electrical impulses in the brain, maintain proper blood pressure and make blood clot when you get cut.

   B. Copper is a major component of the oxygen carrying part of blood cells. It also helps protect our cells from being damaged by certain chemicals in our bodies.

   C. Chlorine carries an electrical charge when dissolved in body fluids allows nerve cells to work. It also helps muscles flex and relax normally.

   D. Hydrogen is extremely important in allowing us to digest our food properly and to absorb many other elements that we need to survive.

   E. Iodine help our wounds heal faster by preventing them from getting infected. It also keeps our thyroid gland healthy.

   F. Carbon is the basic building block of our body. These building blocks can be attached to each other to form long chains, or they can be attached to other elements.

Practice Exercise 4

1. A compound is a substance formed when two or more elements are chemically joined.

2. A. Carbon dioxide - use in the production of carbonated beverages. Formed by the action of yeast or baking powder, carbon dioxide causes the rising of bread dough.

   B. Water - used in the home every day, including water for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens.

   C. Sodium hydroxide - used for cleaning drains that are clogged, cleansing agent used as cleaners for oven, for degreasing the glass and stainless bake ware, as an agent for straightening and relaxing the hair and in the manufacturing procedures of paper and soaps. In the production of bio-diesel it works as a catalyst.

3.

Element	Compound
Characteristics of metals They are strong, malleable, ductile, sonorous, shiny, good conductors of heat and electricity, high melting and boiling point, high densities and all solid at room temperature except mercury. **Characteristics of non-metals** Not strong, malleable, ductile or sonorous. They are brittle. Have lower melting and boiling points than metals. Poor conductors of heat and electricity. Graphite is the only exception and have low densities.	A compound cannot be separated into its constituents by mechanical or physical means. Properties of compound differ entirely from those of its constituent elements. Energy changes are involved in the formation of a compound. The elements in a compound are in a fixed proportion by weight. It is a homogeneous substance. Meaning, it is the same throughout in properties and composition and has a fixed melting and boiling point.

Practice Exercise 5

1. a. Mixtures - are two or more substances that are mixed together but not chemically joined.

   b. Homogeneous mixture - has the same uniform appearance and composition throughout.

   c. Heterogeneous mixture - consists of visibly different substances or phases.

   d. Suspension - is a heterogeneous mixture of larger particles. These particles are visible to the naked eye and will settle out on standing.

   e. Solute - the substance in the smallest amount and the one that dissolves or disperses.

2.

Matter	Mixture type	Example
Solid	Solid mixture	Iron fillings and sulphur
Solid	Liquid mixture	Common salt and water
Solid	Gas mixture	Air entrapped in soil
Liquid	Gas mixture	Oxygen dissolved in water
Liquid	Liquid mixture	Water and alcohol
Gas	Gas mixture	Air containing hydrogen, oxygen, nitrogen, carbon dioxide etc.

3. a. A mixture may be homogeneous or heterogeneous. A homogeneous mixture has a uniform composition throughout its mass. For example, sugar or salt dissolved in water and alcohol in water.
A heterogeneous mixture does not have a uniform composition throughout its mass. There are visible sharp boundaries. For example, oil and water, salt and sand.

b.. The constituents of a mixture can be separated by physical means like filtration, evaporation, sublimation and magnetic separation.

c. In the preparation of a mixture, energy is neither evolved nor absorbed.

d. A mixture has no definite melting and boiling points.

e. The constituents of a mixture retain their original set of properties. For example, a magnet attracts iron fillings.

REVIEW OF TOPIC 1: Atomic Structure

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 1: Matter

- Matter is anything which takes up space and has mass.
- All material on Earth is in three state- solid, liquid and gas.
- A solid has a certain size and shape. You can change the shape of a solid.
- Liquid matter has a size and volume. Volume means it takes up space but does not have a definite shape. It takes the shape of the container. Liquids can flow, be poured and spilled.
- A gas is matter that has no shape or size of its own. It is invisible. Gases have no colour and is all around you.
- Physical properties do not change the chemical nature of matter. Physical properties are readily observable like colour, size, lustre, freezing point, boiling point, melting point, attraction or repulsion to magnets, density or smell.
- Chemical properties are only observable during a chemical reaction.
- Physical change does not produce a new substance. A chemical change or chemical reaction produces a new substance. The new substance is different from the original.
- Signs of chemical change are colour change, gain or release of energy, odour changes and production of gases or solids and not easily reversed.

Lesson 2: Atom

- All matter is made up of atoms. Atoms are the basic building blocks of ordinary matter.
- Atoms are composed of particles called electrons, protons and neutrons. These particles have different properties.
- In the centre of the atom is the nucleus which is a cluster of protons and neutrons. The nucleus makes up almost all of an atom's mass or weight.
- Protons are much larger and heavier than electrons and have a positive charge (+). Neutrons are large and heavy like protons; however neutrons have no electrical charge or they are called electrically neutral (0).
- An extremely powerful force, called the nuclear force, holds the protons together in the nucleus as they naturally repelled one another electrically.
- Whirling at fantastic speeds around the nucleus are electrons. Electrons are tiny, very light particles that have a negative electrical charge.
- A particular atom will have the same number of protons and electrons.
- Electrons are arranged in shells and orbits around the nucleus. There is a definite arrangement of the electrons in these shells and a maximum number of electrons possible in each shell.
- Dot diagrams are made for neutral atoms, meaning atoms that have the same number of electrons as protons.

Lesson 3: Elements

- Elements are substances that cannot be broken down or decomposed into simpler substances.
- Elements can be present in nature as solids, liquids or gases. The atmosphere is mostly made up of the elements nitrogen (~78%) and oxygen (~21%).
- Calcium is important in building and maintaining strong bones and teeth, helps control muscle growth and electrical impulses in the brain, maintain proper blood pressure and make blood clot when your skin gets cut.
- Carbon is the basic building block of our body. These building blocks can be attached to each other to form long chains, or they can be attached to other elements.
- Chlorine carries an electrical charge when dissolved in body fluids allows nerve cells to work. It also helps muscles flex and relax normally.
- Copper is a major component of the oxygen carrying part of blood cells. It also helps protect our cells from being damaged by certain chemicals in our bodies.
- Fluorine is an element that the body uses to strengthen bones and teeth.
- Hydrogen is extremely important in allowing us to digest our food properly and to absorb the many other elements that we need to survive.
- Iodine help our wounds heal faster by preventing them from getting infected. It also keeps our thyroid gland healthy.
- The element iron is used by the body to make tendons and ligaments.
- Nitrogen plays an important role in digestion of food and growth.
- People need to breathe oxygen to survive, but plants need this element too. Without oxygen, plants will not survive. Without plants, we would not have food to eat.

Lesson 4: Compounds

- A compound is a substance formed when two or more elements are chemically joined.
- Carbon dioxide’s greatest use as a chemical is in the production of carbonated beverages. Formed by the action of yeast or baking powder, carbon dioxide causes the rising of bread dough.
- Sugar is used in baking. Its role becomes more complex as it also adds volume, tenderness, texture, colour, and acts as a preservative.
- Sodium hydroxide is also used for cleaning drains that are clogged, cleansing agent used as cleaners for oven, for degreasing the glass and stainless bake ware, as an agent for straightening and relaxing hair and in the manufacturing procedures of paper and soaps. In the production of bio-diesel it works as a catalyst.
- The largest use of ammonia is in fertilizers, for pulping wood, as a source of nitrogen needed for yeast and micro-organisms, as slime and mould preventative in tanning liquors and commercial and household cleaners and detergents.
- Water is used in the home every day, including water for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens.

Lesson 5: Mixtures

- Mixtures are two or more substances that are mixed together but not chemically joined.
- A homogeneous mixture has the same uniform appearance and composition throughout.
- A colloid is a homogeneous solution with intermediate particle size between a solution and a suspension.
- A heterogeneous mixture consists of visibly different substances or phases.
- Suspension is a heterogeneous mixture of larger particles. These particles are visible to the naked eye and will settle out on standing.
- The substance in the smallest amount and the one that dissolves or disperses is called the solute. The substance in the larger amount is called the solvent.
- The greatest concentration of a solute in a solvent is the solubility of a solution. When the solvent contains the most solute it can hold, it is said to be saturated; if it has less solute than it can hold, it is unsaturated.
- The constituents of a mixture can be separated by physical means like filtration, evaporation, sublimation and magnetic separation.
- In the preparation of a mixture, energy is neither evolved nor absorbed.
- A mixture has no definite melting and boiling points.
- The constituents of a mixture retain their original set of properties.
- In a solid matter, the type of mixtures are solid, liquid and gas.
- In a liquid matter, the type of mixtures are liquid and gas.
- In a gas matter, the type of mixture is only gas.

REVISE WELL AND THEN DO TOPIC TEST 1 IN YOUR ASSIGNMENT 4.

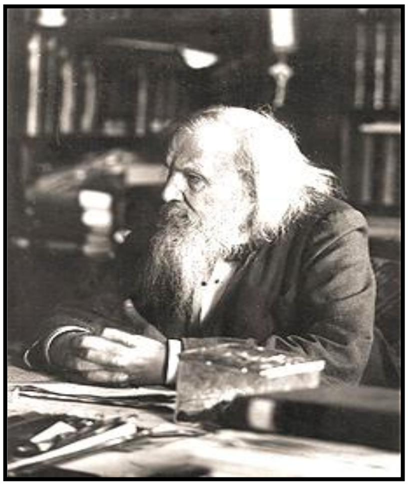
TOPIC 2

THE PERIODIC TABLE

In this topic you will learn about:

- **the development of the Periodic Table**
- **periods and groups in the Periodic Table**
- **symbols and formulae**
- **metals and non-metals**

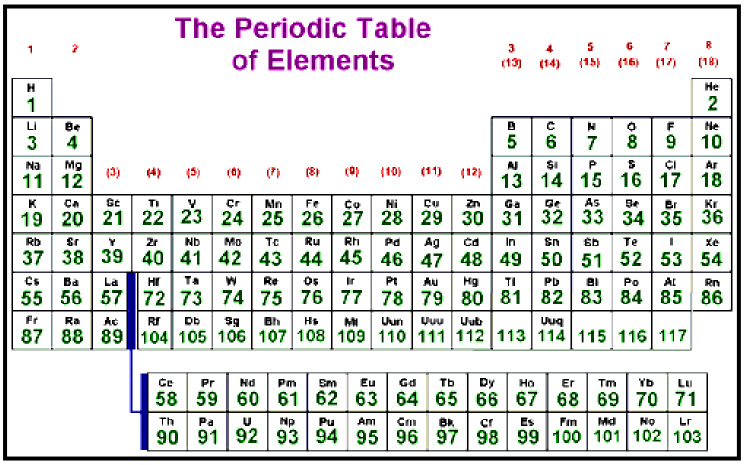
INTRODUCTION TOPIC 2: THE PERIODIC TABLE



Dimitri Mendeleev was born on February 7th 1834 in Tobolsk, a Town in Siberia. In 1869 at the age of 35 the famous Russian Scientist perceived a totally new classification method "The Periodic Table"; he included all the 65 elements known in his time by their atomic weights and chemical valency.

Mendeleev then went even further, using the remaining gaps and spaces in his Periodic Table. He correctly concluded that a further group of yet unknown elements must exist in order to fill in the gaps in his Periodic Table. This group, we now know as the lanthanides, and is Group six of our modern Standardised Periodic Table.

Fifty years after Dimitri Mendeleev created the Periodic cable, a British scientist Henry Moseley discovered that the number of protons in the nucleus of a particular type of atom was always the same. When atoms are arranged via their atomic number, few remaining problems with Mendeleev's original Periodic Table disappeared. Due to Moseley's work, the modern Periodic Table is based on the atomic numbers of elements rather than atomic mass.



Dimitri Mendeleev's work on the Periodic Table recognised He had clearly left his mark on modern science. Indeed all modern Scientists are familiar with Standardised version of his Periodic Table. Mendeleyev's homeland, Russia, has recognised the significance of his work by naming the "Mendeleyev University of Chemical Technology" in Moscow in his honour.

The standardised Periodic Table in use today was agreed by the International Union of Pure Applied Chemistry, IUPAC, in 1985 and now recognises more periods and elements than Dimitri Mendeleev knew in his day but still all fitting into his concept of the "Periodic Table".

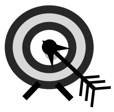
Some questions will arise such as

- What are the historical developments of the Periodic Table?
- How would you explain the arrangement of elements in the Periodic Table?
- What are the symbols and formulae of common elements and compounds?

In this Topic, you will find the answers to these questions and other questions relating to the periodic table.

Lesson 6: The Development of the Periodic Table

Welcome to Topic 2, The Periodic Table. In Topic 1, you have learnt the different atomic structure of atoms. You also studied the chemical and physical properties of matter, the sub atomic particles of atom, and its arrangement in shells, the properties and uses of some elements, the characteristics of compounds compared to elements and the different types of mixtures and solutions. For this lesson you will study the development of the Periodic Table.

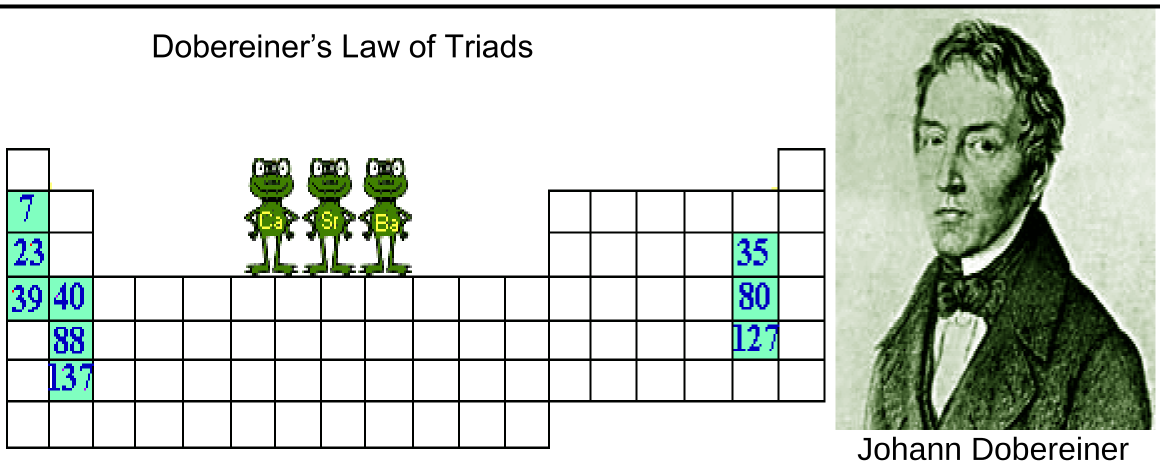


Your Aims:

- discuss the historical development of the periodic table
- explain the work of Newlands, Mendeleev and Moseley in the development of the periodic table

Since the earliest days of chemistry, attempts have been made to arrange the known elements in ways that revealed similarities between them. However, it required the genius of Mendeleev to see that arranging elements into patterns was not enough; he realised that there was a natural plan in which each element has its allotted place, and this applies not only to the known elements but to some that were still undiscovered. The Periodic Table did not end with Mendeleev but continued to take shape for the next 75 years. Today we have the so-called long form of the table.

Dobereiner's Law of Triads



Johann Dobereiner

The development of the Periodic Table begins with German chemist **Johann Dobereiner** (1780-1849) who grouped elements based on similarities. Calcium (atomic weight 40), strontium (atomic weight 88), and barium (atomic weight 137) possess similar chemical properties. Dobereiner noticed the atomic weight of strontium fell midway between the weights of calcium and barium:(40 + 137) ÷ 2 = 88

Ca	Sr	Ba
40	88	137

Dobereiner noticed the same pattern for the alkali metal triad (Li/Na/K) and the halogen triad (Cl/Br/I).

Li	Na	K	Cl	Br	I
7	23	39	35	80	127

In 1829 Dobereiner proposed the **Law of Triads***: Middle element in the triad had atomic weight that was the average of the other two members. Soon other scientists found chemical relationships extended beyond triads. Fluorine was added to Cl/Br/I group; sulphur, oxygen, selenium and tellurium were grouped into a family; nitrogen, phosphorus, arsenic, antimony, and bismuth were classified as another group.

First Periodic Table

It was a 19th century geologist who first recognised periodicity in the physical properties of elements. **Alexandre Beguyer de Chancourtois** (1820-1886), Professor of Geology at the School of Mines in Paris, published in 1862 a list of all the known elements. The list was constructed as a helical graph wrapped around a cylinder. Elements with similar properties occupied positions on the same vertical line of cylinder (the list also included some ions and compounds). Using geological terms and published without the diagram, de Chancourtois ideas were completely ignored until the work of Mendeleev.

Law of Octaves

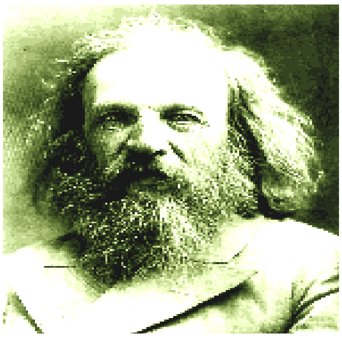
English chemist **John Newlands** (1837-1898), having arranged the 62 known elements in order of increasing atomic weights, noted that after interval of eight elements similar physical/chemical properties reappeared. Newlands was the first to formulate the concept of periodicity in the properties of the chemical elements. In 1863 he wrote a paper proposing the **Law of Octaves*** where elements exhibit similar behaviour to the eighth element following it in the table.

Newlands' Arranged Elements in Octaves

H	F	Cl	Co/Ni	Br	Pd	I	Pt/Ir
Li	Na	K	Cu	Rb	Ag	Cs	Tl
G	Mg	Ca	Zn	Sr	Cd	Ba/V	Pb
Bo	Al	Cr	Y	Ce/La	U	Ta	Th
C	Si	Ti	In	Zn	Sn	W	Hg
N	P	Mn	As	Di/Mo	Sb	Nb	Bi
O	S	Fe	Se	Ro/Ru	Te	Au	Os

John Newlands

Mendeleev's Periodic Table



Mendeleev

Then in 1869, Russian chemist **Dimitri Mendeleev** (1834-1907) proposed arranging elements by **atomic weights** and properties (**Lothar Meyer** independently reached similar conclusion but published results after Mendeleev). Mendeleev's Periodic Table of 1869 contained 17 columns with two partial periods of seven elements each (Li-F & Na-Cl) followed by two nearly complete periods (K-Br & Rb-I).

In 1871, Mendeleev revised the 17-**group*** table with eight columns (the eighth group consisted of transition elements). This table exhibited similarities not only in small units such as the triads, but showed similarities in an entire network of vertical, horizontal, and diagonal relationships.

The table contained gaps but Mendeleev predicted the discovery of new elements. In 1906, Mendeleev came within one vote of receiving the Nobel Prize in chemistry.

Mendeleev's Periodic Table

Group / Period	I	II	III	IV	V	VI	VII	VIII
1	H=1							
2	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl=35.5	
4	K=39	Ca=40	?=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56,Co=59 Ni=59
5	Cu=63	Zn=65	?=68	?=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	?=100	Ru=104,Rh=104 Pd=106
7	Ag=108	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140				
9								
10			?Er=178	?La=180	Ta=182	W=184		Os=195,Ir=197 Pt=198
11	Au=199	Hg=200	Tl=204	Pb=207	Bi=208			
12				Th=231		U=240		

Noble Gases

Lord Rayleigh (1842-1919) and **William Ramsey** (1852-1916) greatly enhanced the Periodic Table by discovering the "inert gases." In 1895 Rayleigh reported the discovery of a new gaseous element named argon. This element was chemically inert and did not fit any of the known periodic groups. Ramsey followed by discovering the remainder of the inert gases and positioning them in the Periodic Table. So by 1900, the Periodic Table was taking shape with elements arranged by atomic weight.

For example, 16g oxygen reacts with 40g calcium, 88g strontium, or 137g barium. If oxygen used as the reference, then Ca/Sr/Ba assigned atomic weights of 40, 88, and 137 respectively. Rayleigh (physics) and Ramsey


Rayleigh


Ramsey

(chemistry) were awarded Nobel prizes in 1904. The first inert gas compound was made in 1962 (xenon tetra fluoride) and numerous compounds have followed. Today the group is more appropriately called the **noble gases.**

Moseley's Periodic Table

Henry Moseley (1887-1915) arranged the elements according to increasing atomic numbers and not atomic masses and some of the inconsistencies associated with Mendeleev's table were eliminated.

The modern Periodic Table is based on Moseley's **Periodic Law** (atomic numbers). At age 28, Moseley was killed in action during World War I and as a direct result Britain adopted the policy of exempting scientists from fighting in wars. Shown below is a Periodic Table from 1930.

Henry Moseley

Group 0	I a b	II a b	III a b	IV a b	V a b	VI a b	VII a b	VIII
	H 1							
He 2	Li 3	Be 4	B 5	C 6	N 7	O 8	F 9	
Ne 10	Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17	
Ar 18	K 19 / Cu 29	Ca 20 / Zn 30	Sc 21 / Ga 31	Ti 22 / Ge 32	V 23 / As 33	Cr 24 / Se 34	Mn 25 / Br 35	Fe 26, Co 27, Ni 28
Kr 36	Rb 37 / Ag 47	Sr 38 / Cd 48	Y 39 / In 49	Zr 40 / Sn 50	Nb 41 / Sb 51	Mo 42 / Te 52	– / I 53	Ru 44, Rh 45, Pd 46
Xe 54	Cs 55 / Au 79	Ba 56 / Hg 80	57-71* / Tl 81	Hf 72 / Pb 82	Ta 73 / Bi 83	W 74 / Po 84	Re 75 / –	Os 76, Ir 77, Pt 78
Rn 86	–	Ra 88	Ac 89	Th 90	Pa 91	U 92		

Modern Periodic Table

The last major change to the Periodic Table resulted from **Glenn Seaborg's** work in the middle of the 20th century. Starting with plutonium in 1940, Seaborg discovered transuranium elements 94 to 102 and reconfigured the Periodic Table by placing the **lanthanide/actinide series** at the bottom of the table. In 1951 Seaborg was awarded the **Nobel Prize** in chemistry and element 106 was later named seaborgium (Sg) in his honour.

Why is Mendeleev given Credit in Modern Text Books?

Mendeleev's Table allowed for and was capable of adjusting to future discoveries.

- Noble gases, new column in 1894-1901.
- Incorporation of the rare earth elements.
- Moseley's atomic number in 1914.
- Bohr atom and electronic structure in 1913.
- Discovery of synthetic elements 1939 to present (element 110, 1994).

Activity: **Now test yourself by doing this activity.**

Answer the questions briefly.

Discuss the works of

1. Johann Dobereiner

2. John Newlands

3. Dimitri Mendeleev

D. Henry Moseley

E. Lord Rayleigh and William Ramsey

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 6.

Summary

You have come to the end of lesson 6. In this lesson you have learn that:

- the development of the periodic table begins with German chemist Johann Dobereiner (1780-1849) who grouped elements based on similarities.
- in 1829, Dobereiner proposed the Law of Triads: Middle element in the triad had atomic weight that was the average of the other two members.
- alexandre Beguyer de Chancourtois (1820-1886), published in 1862 a list of all the known elements. The list was constructed as a helical graph wrapped around a cylinder. Elements with similar properties occupied positions on the same vertical line of cylinder.
- english chemist John Newlands (1837-1898), having arranged the 62 known elements in order of increasing atomic weights, noted that after interval of eight elements similar physical/chemical properties reappeared. In 1863 he wrote a paper proposing the Law of Octaves where elements exhibit similar behaviour to the eighth element following it in the table.
- russian chemist Dimitri Mendeleev (1834-1907) proposed arranging elements by atomic weights and properties. In 1871 Mendeleev revised the 17-group table with eight columns (the eighth group consisted of transition elements). This table exhibited similarities not only in small units such as the triads, but showed similarities in an entire network of vertical, horizontal, and diagonal relationships.
- lord Rayleigh (1842-1919) and William Ramsey (1852-1916) greatly enhanced the periodic table by discovering the "inert gases."
- henry Moseley (1887-1915) arranged the elements according to increasing atomic numbers and not atomic masses and some of the inconsistencies associated with Mendeleev's table were eliminated. The modern periodic table is based on Moseley's Periodic Law (atomic numbers).
- the last major change to the periodic table resulted from Glenn Seaborg's work in the middle of the 20th century. Starting with plutonium in 1940, Seaborg discovered trans uranium elements 94 to 102 and reconfigured the periodic table by placing the lanthanide/actinide series at the bottom of the table.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

Answer the following questions:

1. Discuss the historical development of the Periodic Table.

- ______
- ______
- ______
- ______
- ______
- ______
- ______

2. Explain the following.

a. Periodic Law

______

b. Law of Octaves

______

c. Law of Triads

______

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to activity

A. Johann Dobereiner

The development of the Periodic Table begins with German chemist Johann Dobereiner (1780-1849) who grouped elements based on similarities. Dobereiner noticed the atomic weight of strontium fell midway between the weights of calcium and barium. He also noticed the same pattern for the alkali metal triad (Li/Na/K) and the halogen triad (Cl/Br/I). In 1829 Dobereiner proposed the **Law of Triads** where middle element in the triad had atomic weight that was the average of the other two members. Soon other scientists found chemical relationships extended beyond triads. Fluorine was added to Cl/Br/I group; sulphur, oxygen, selenium and tellurium were grouped into a family; nitrogen, phosphorus, arsenic, antimony, and bismuth were classified as another group.

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English chemist John Newlands (1837-1898), having arranged the 62 known elements in order of increasing atomic weights, noted that after interval of eight elements similar physical/chemical properties reappeared. Newlands was the first to formulate the concept of periodicity in the properties of the chemical elements. In 1863 he wrote a paper proposing the **Law of Octaves** where elements exhibit similar behaviour to the eighth element following it in the table.

C. Dimitri Mendeleev

Russian chemist Dimitri Mendeleev (1834-1907) proposed arranging elements by **atomic weights** and properties. Mendeleev's Periodic Table of 1869 contained 17 columns with two partial periods of seven elements each (Li-F & Na-Cl) followed by two nearly complete periods (K-Br & Rb-I). In 1871 Mendeleev revised the 17-group table with eight columns. This table exhibited similarities not only in small units such as the triads, but showed similarities in an entire network of vertical, horizontal, and diagonal relationships. The table contained gaps but Mendeleev predicted the discovery of new elements.

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Henry Moseley (1887-1915) arranged the elements according to increasing atomic numbers and not atomic masses and some of the inconsistencies associated with Mendeleev's table were eliminated. The modern Periodic Table is based on Moseley's **Periodic Law** (atomic numbers).

E. Lord Rayleigh and William Ramsey

Lord Rayleigh (1842-1919) and William Ramsey (1852-1916) greatly enhanced the Periodic Table by discovering the "inert gases." In 1895 Rayleigh reported the discovery of a new gaseous element named argon. This element was chemically inert and did not fit any of the known periodic groups. Ramsey followed by discovering the remainder of the inert gases and positioning them in the Periodic Table. So by 1900, the Periodic Table was taking shape with elements were arranged by atomic weight. The first inert gas compound was made in 1962. Today the group is more appropriately called the **noble gases.**

Lesson 7: Periods and Groups in the Periodic Table

From the previous lesson, you have learnt the evolvement of the Periodic Table. You have discussed the works of Newlands, Mendeleev and Moseley in the development of modern Periodic Table. You also explained periodic law, law of octaves and the law of triads. For this lesson you will study the periods and groups in the Periodic Table.

Your Aims:

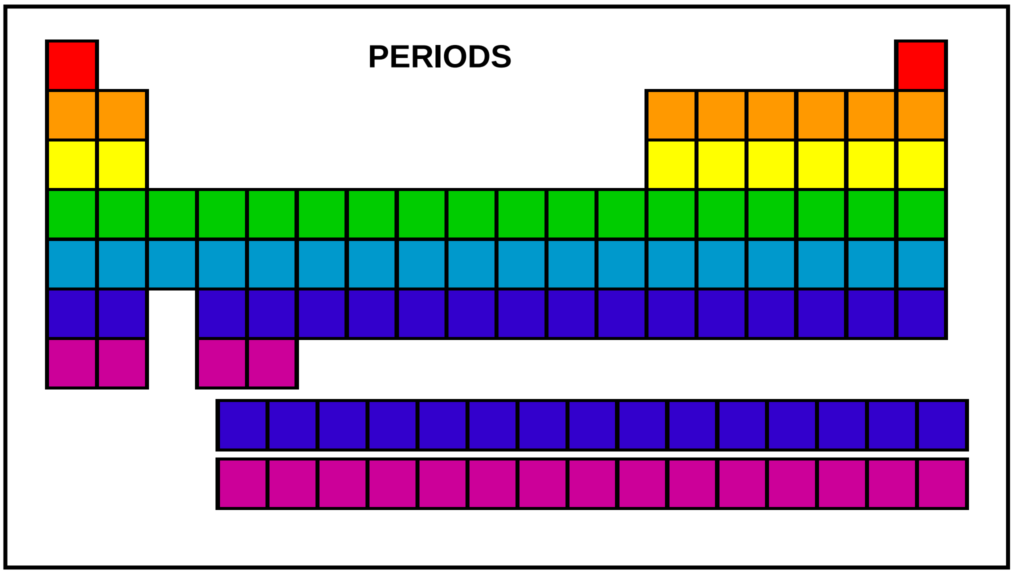
- describe the arrangement of elements in periods and groups
- explain properties and trends of elements
- discuss the valence electrons

As you probably saw, the **Periodic Table** is organized like a big grid. The **elements** are placed in specific places because of the way they look and act. If you have ever looked at a grid, you know that there are rows (left to right) and columns (up and down). The Periodic Table has rows and columns, too, and they each mean something different.

Periods

Even though they skip some squares in between, all of the **rows go left to right.** When you look at a Periodic Table, each of the **rows** is considered to be a different **period**. In the Periodic Table, elements have something in common if they are in the same row. All of the elements in a period have the same number of **atomic orbitals**. Every element in the top row (the first period) has one orbital for its **electrons**. All of the elements in the second row (the second period) have two orbitals for their electrons. It goes down the Periodic Table like that. At this time, the maximum number of electron orbitals or electron shells for any element is seven.

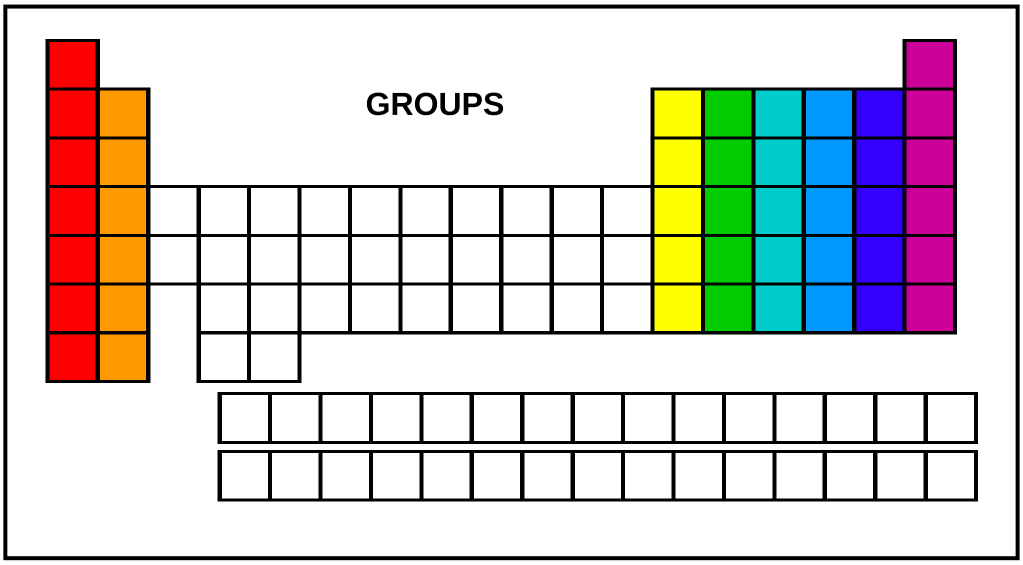
The period of an element signifies the highest energy level an electron in that element occupies in an unexcited state. Generally, within a given period, the chemical activity of metals increases with the group number, while the chemical activity of non-metals within a given period decreases with the group number.



Groups

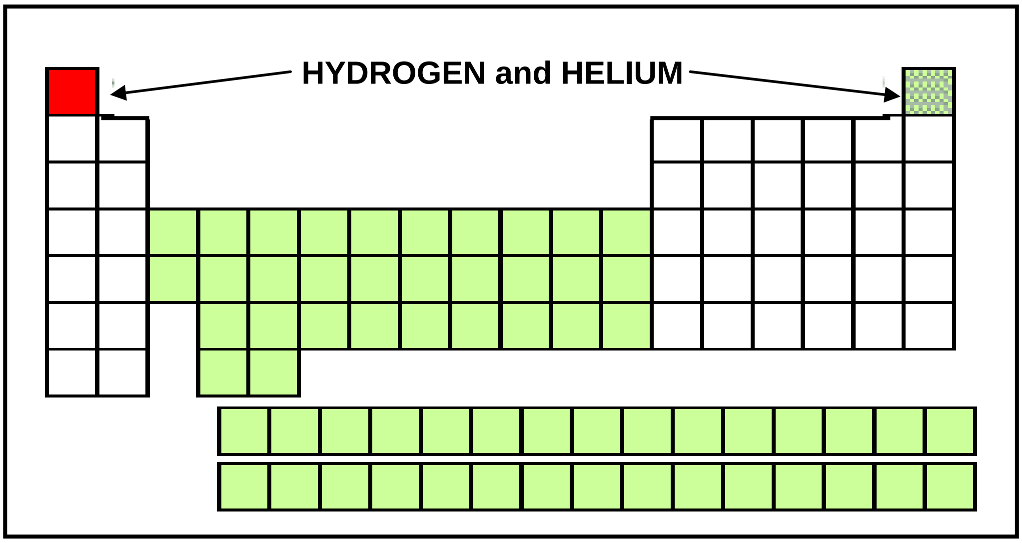
The Periodic Table has a special name for its **columns,** too. When a **column goes from top to bottom,** it is called a **group**. The elements in a group have the same number of electrons in their outer orbital. Every element in the first column (group one) has one electron in its outer shell. Every element on the second column (group two) has two electrons in the outer shell. As you keep counting the columns, you will know how many electrons are in the outer shell. There are some exceptions to the order when you look at the **transition elements.**

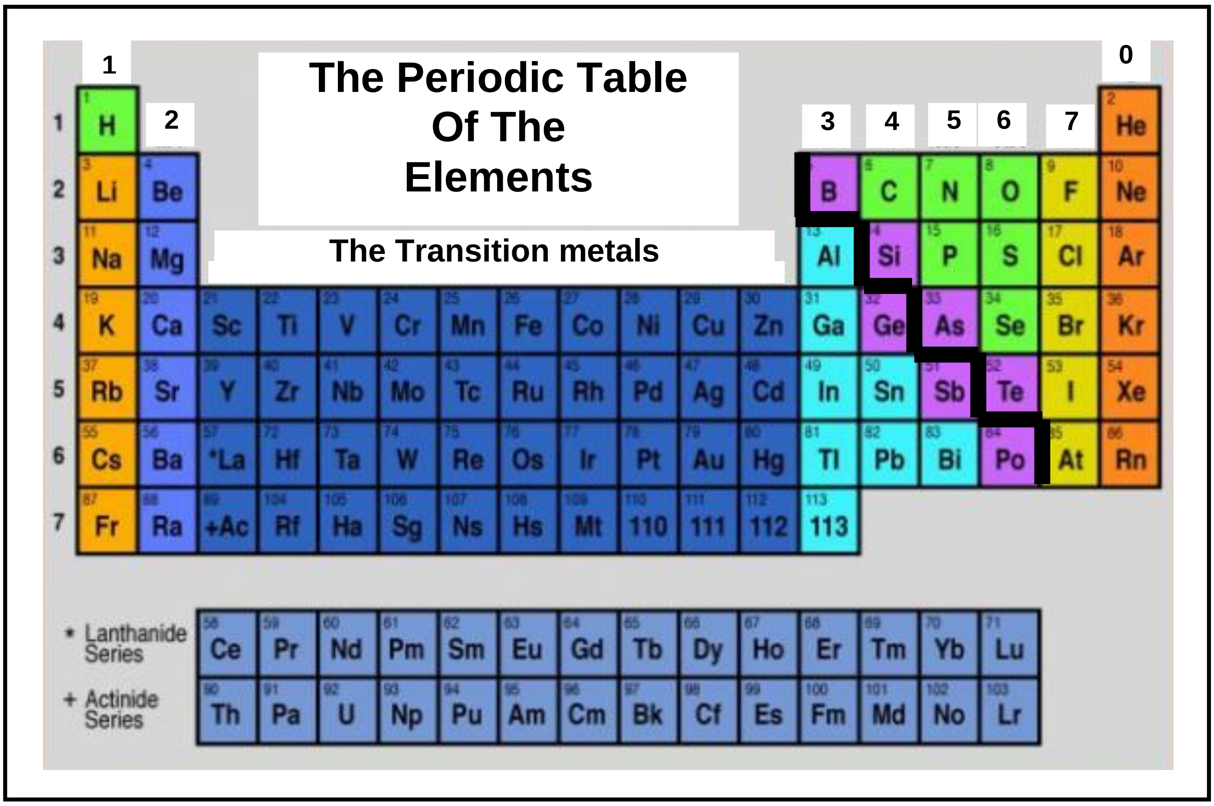
Properties within each individual group are similar, but nevertheless vary within a group. Generally chemical activity decreases as the period increases a non-metal group and increases as the period increases within a metal group. The first element in a group is always an active metal; the last is always an inactive non-metal.



Two at the top

Hydrogen (H) and helium (He) are special elements. **Hydrogen** can have talents and electrons of two groups, one and seven. To scientists, hydrogen is sometimes has missing electron, and sometimes it has an extra. **Helium** is different from all of the other elements. It can only have two electrons in its outer shell. Even though it only has two, it is still grouped with elements that have eight (**inert gases**). The elements in the centre section are called transition elements. They have special electron rules.





The table has eight groups of elements, plus a block of **transition metals***. The eight groups are numbered. Group 4 contains the elements carbon (C), silicon (Si), germanium (Ge). Tin (Sn) and lead (Pb). Their atoms each have 4 electrons in the outer shell. The atoms of group 5 elements each have 5 electrons in the outer shell and so on.

Some of the groups have special names:

Group 1 is often called **the alkali metals**.
Group 2 is the **alkaline earth metals.**
Group 7 is the **halogens**.
Group 0 is the **noble gases**.

Look at the **zigzag lines** through the groups. It separates the **metals** from the **non-metals**. The metals are on the left.

The horizontal rows in the table are called periods. Period 2 contains lithium (Li), beryllium (Be), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F) and neon (Ne).

The transition metals – The atoms of these have more complicated electron arrangements. Note that the group contains many common metals such as iron (Fe), nickel (Ni) and copper (Cu).

Properties and trends of the elements

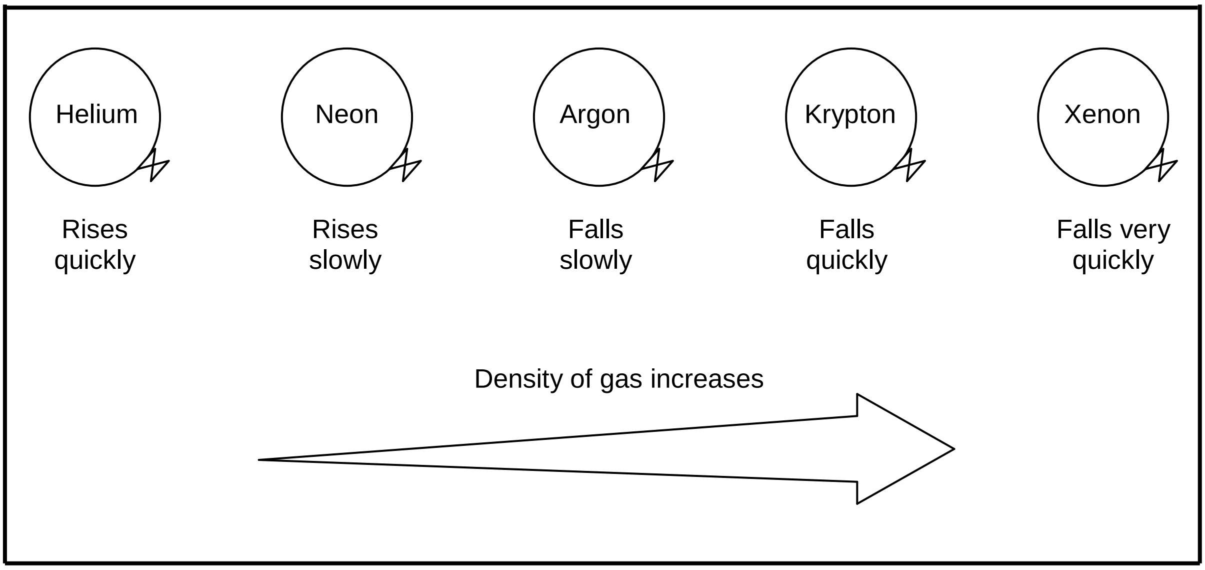
The Periodic Table helps predict some properties of the elements compared to each other. Atom size decreases as you move from left to right across the table and increases as you move down a column. Energy required to remove an electron from an atom increases as you move from left to right and decreases as you move down a column. The ability to form a chemical bond increases as you move from left to right and decreases as you move down a column.

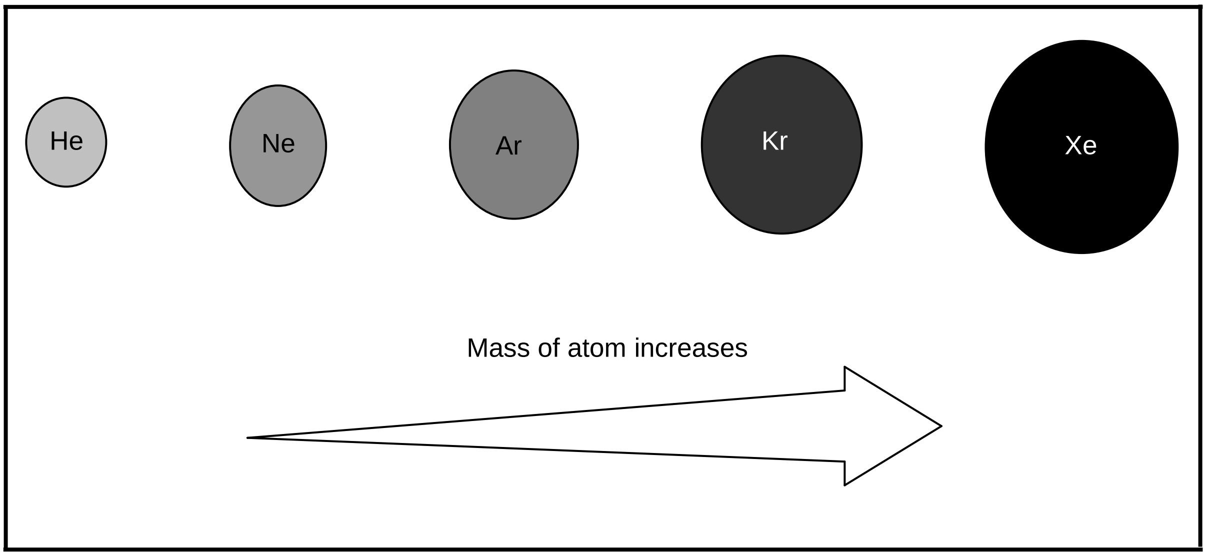
Group 0 – the noble gases

These elements are all:

- non-metals
- gases
- colourless

The striking thing about them is how **unreactive** they are. They will not normally react with anything. If you filled five balloons with the same volume of each gas at the same temperature and let them go, this is what you would find:

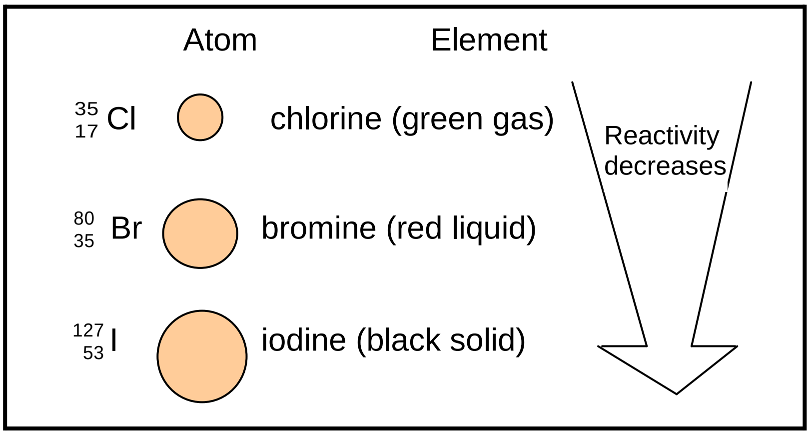




This shows that the density of the gases increases from helium to xenon. This is an example of **trend** in the Periodic Table.

Remember
As you go down Group 0 the density or 'heaviness' of the gases increases.

Group 7 – the halogens
Chlorine, bromine and iodine are the most common halogens. They are all non-metals and poisonous. Look at these trends.

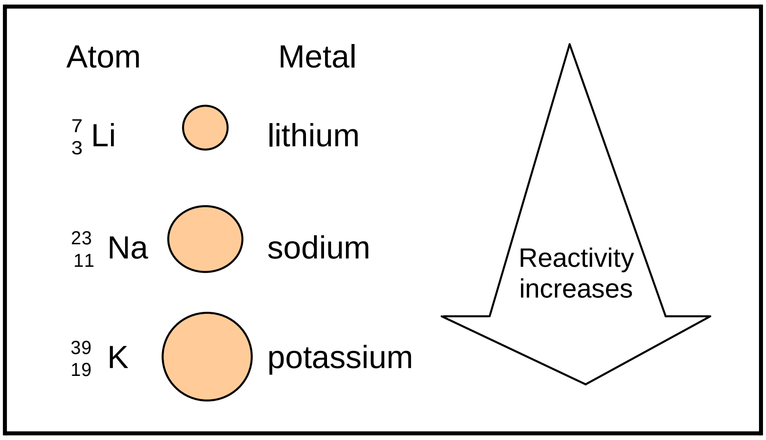


The halogens have similar properties and are reactive. Of the three, chlorine is the most reactive while iodine is the least reactive. The reactivity of the halogens decreases because of size.

Remember
In halogens, the reactivity decreases from top to bottom as the atoms get larger.

Group 1 – the alkali metals
These elements are all:
- soft metals that can be cut with a knife
- so light they float in water
- silvery and shiny when freshly cut but quickly tarnish
- have low melting and boiling points

Look at these trends.

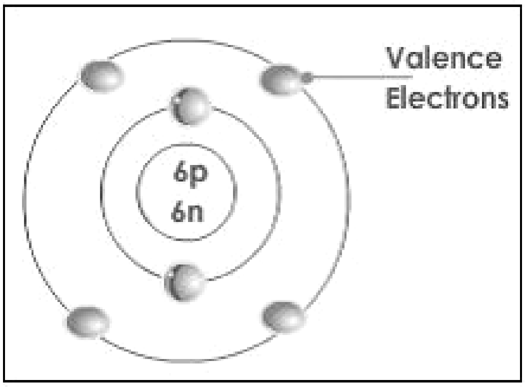


Alkali metals have similar properties. Of the three metals above, potassium is the most reactive while lithium is the least reactive. As we go down Group 1, the reactivity increases as atoms get larger. (This is the opposite of Group 7.)

Remember
For both alkali and alkaline earth metals, the reactivity increases from top to bottom as the atoms get larger.

Valence electrons

The outermost shell of an atom is called its Valence shell. It is the decisive shell during a chemical reaction. The electrons of this outermost shell are involved during chemical combinations; electrons are either given out from the outermost shell, or accepted into the outermost shell, or shared with the electrons in the outermost shell of another element.



Significance of valence electrons

- Valence electrons of an atom are responsible for chemical reactions as they take part in them.
- Elements having same number of valence electrons in their atoms possess similar chemical properties. All alkali metals have one valence electron in their atom. Thus, their chemical properties are similar.

Alkali metal	Atomic number	Valence electrons
Lithium (Li)	3	1
Sodium (Na)	11	1
Potassium (K)	19	1

- The number of valence electrons and valance shell in an atom determines its position in the Periodic Table that is the group and period to which the element belongs.
- Elements having 1, 2 or 3 electrons in the valence shell are metals. Exception is H and He. Elements having 4 to 7 electrons in their valence shell are non-metals.

Counting valence electrons

The number of valence electrons is just how many electrons an atom has in its outer shell. All the elements in each Group (column) have the same number of electrons in their outer shells.

All the elements in Group 1 (first column) all have a single (1) valence electron (H, Li, Na, K and so on).

Group 2 (second column) elements all have 2 valence electrons (Be, Mg, Ca, Sr, and so on.

Skipping over the gap (Transition metal), go to Group 3 elements, which all have 3 valence electrons (B, Al, Ga and so on).

The elements in Group 4 (the next column) C, Si, Ge, and so on. all have 4 valence electrons.

The elements in Group 5 (the next column) N, P, As, and so on. all have 5 valence electrons.

O, S, Se and the others in this column are Group 6, all have 6 valence electrons

Group 7 (the halogens) F, Cl, Br, and so on is in the next to last column, have 7 electrons.

The Group 0 (noble gases) Ne, Ar, Kr, etc. is in the right-most column; all have 8 electrons in their outer most shell except for He, which only has 2 electrons.

If the outermost shell of an atom is completely filled, its valency = 0. The outermost shells of the noble gases helium, neon, argon, krypton and so on. are completely filled. Hence their valency is zero. Such elements are very un-reactive and inert by nature.

Activity: **Now test yourself by doing this activity.**

Circle the letter of the correct answer.

1. Where in the Periodic Table are you most likely to find an element that shows no reaction with other elements?

   A. Group 1 B. Group 7

   C. Group 0 D. Transition metals

2. The 'Alkali Metals' are all in the same Group of the Periodic Table because they are all

   A. soft silvery solid.
   B. reacts fast with water.
   C. form an ionic chloride.
   D. has one electron in the outer shell.

3. Which of the following elements is a liquid metal at room temperature and pressure?

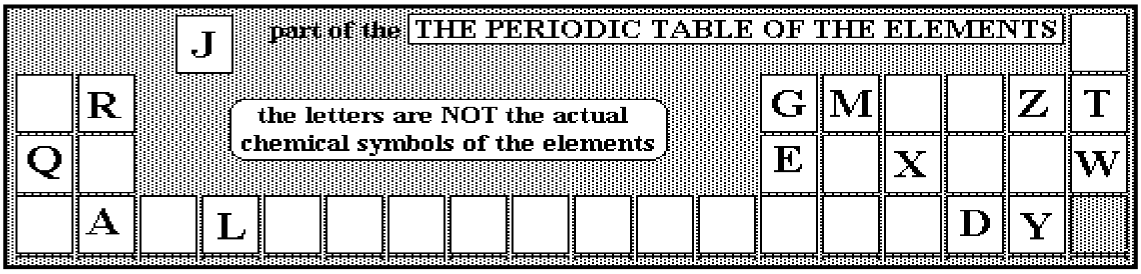
   A. Carbon B. Copper

   C. Bromine D. Mercury

4. The 'Noble Gas' non-metals are all in the same Group of the Periodic Table because they all

   A. are colourless gases
   B. are reactive elements
   C. have a full inner shell of electrons
   D. have a full outer shell of electrons

5. Which of the elements shown are both likely to be metals?



   A. Elements Q and R
   B. Elements Z and Y
   C. Elements T and W
   D. Elements G and E

6. Atoms of elements in a group on the Periodic Table have similar chemical properties. This similarity is most closely related to the atoms'

   A. atomic masses
   B. atomic numbers
   C. number of valence electrons
   D. number of principal energy levels

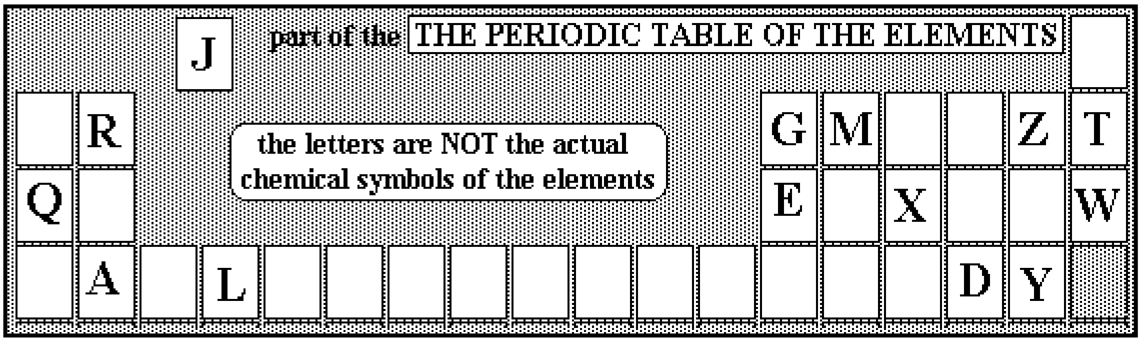
7. Where in the Periodic Table are you most likely to find an element that is a soft silvery solid?

   A. Group 1
   B. Group 7
   C. Group 0
   D. Transition metals

8. Which statement is **true** about the modern Periodic Table?

   A. Most elements are non-metals.
   B. The elements are laid out in order of relative atomic mass.
   C. Elements in the same group have the same number of electrons in the outer shell.
   D. From left to right, elements in the same period, use an increasing number of electron shells.

9. Which of the elements shown are in the same period?



A. Elements Q and R
B. Elements G and M
C. Elements M and X
D. Elements R and A

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 7.

Summary

You have come to the end of lesson 7. In this lesson you have learnt that:

- the periodic table has eight groups of elements which are numbered, plus a block of transition metals.
- some of the groups have special names:
  Group 1 is often called the alkali metals, group 2 is the alkaline earth metals, group 7 is the halogens and group 0 is the noble gases.
- the zigzag line through the groups separates the metals from the non-metals. The metals are on the left.
- when a column goes from top to bottom, it is called a group. The elements in a group have the same number of electrons in their outer orbital.
- the horizontal rows in the table are called periods. All of the elements in a period have the same number of atomic orbitals. Every element in the top row (the first period) has one orbital for its electrons.
- hydrogen (H) and helium (He) are special elements.
- as you go down Group 0, the density or 'heaviness' of the gases increases.
- in halogens, the reactivity decreases from top to bottom as the atoms get larger.
- for both alkali and alkaline earth metals, the reactivity increases, from top to bottom as the atoms get larger.
- the outermost shell of an atom is called its Valence shell.
- elements having 1, 2 or 3 electrons in the valence shell are metals. Exception is H and He. Elements having 4 to 7 electrons in their valence shell are non-metals.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions:

1. Describe the arrangement of elements in periods and groups.

   a. Periods

   ____
   ____
   ____
   ____
   ____

   b. Groups

   ____
   ____
   ____
   ____
   ____

2. Explain the trends in the following:

   a. Alkali and Alkaline earth metals

   ____
   ____
   ____

   b. Group 0 (Noble gases)

   ____
   ____
   ____

   c. Group 7 (Halogens)

   ____
   ____
   ____

3. Discuss valence electrons.

____
____
____
____
____

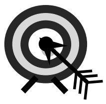
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to activity

1. C
2. D
3. D
4. D
5. A
6. C
7. A
8. C
9. B

Lesson 8: Symbols and Formulae

From the previous lesson, you have studied the arrangement of elements in periods and groups in the Periodic Table. You have explained the trends of these elements and also discussed about the valence electrons which is also called the combining power. For this lesson you will study the different symbols and formulae.



Your Aims:

- differentiate symbol from formula
- explain the rules in naming compounds

Difference Between Symbol and Formula

A symbol is used as a short hand to represent a single element. For example oxygen is O, phosphorous is P, and iron is Fe.

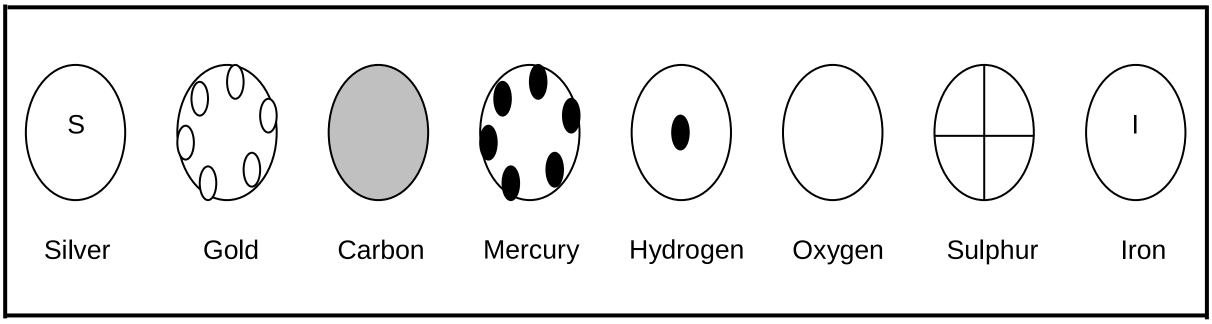
A formula uses chemical symbols to show which elements are in a molecule or compound and how much. For example the oxygen molecule is O_2, meaning there are two oxygen atoms, water is H_2O, meaning there are two hydrogen atoms and one oxygen atom and methane is CH_4, meaning there is one carbon atom and 4 hydrogen atoms.

Names and Symbols of Elements

In 1803, John Dalton, an English schoolmaster put forward his theory about atoms. (Atom comes from the Greek word 'atomos' meaning so tiny that it cannot be divided further). His theory states that:

- All matter is composed of atoms.
    - Atoms of the same element (a substance that cannot be divided into simpler substances) are identical in size and mass.
    - Atoms of one element are different from atoms of another element.

He used the following picture symbols to represent the elements he was studying.



Several years later a Swedish chemist, Berzelius, devised a more logical and efficient method of representing the elements, the one which we use today. The method involves the use of either one capital letter or one capital letter followed by a small letter. Some of the symbols are derived from the letters of the Latin language.

For example, we use the symbol Fe for Iron (Ferrum is the Latin for Iron) and K for Potassium (Kalium is the Latin for Potassium). Many of the symbols are derived from the letters of English words, such as the symbol C for Carbon and Co for Cobalt.

A few elements are named after the famous scientists; Einsteinium (Es) for example is named after the famous scientist Albert Einstein.You can probably guess the name of the country that the element Americium (Am) is named after.

Here are the list of names and symbols of some elements that are metals.

Name	Symbol
Calcium	Ca
Mercury	Hg
Gold	Au
Silver	Ag
Copper	Cu
Tin	Sn

Name	Symbol
Nickel	Ni
Magnesium	Mg
Platinum	Pt
Lead	Pb
Aluminium	Al
Vanadium	V

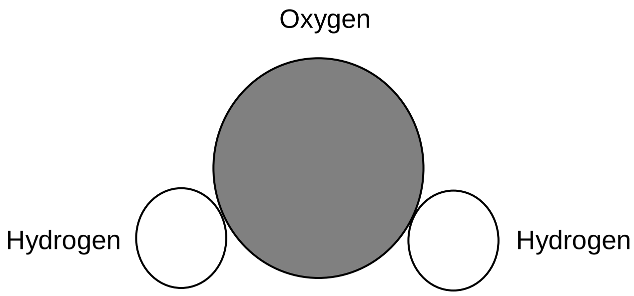
And here are the list of names and symbols of some non-metallic elements.

Name	Symbol
Silicon	Si
Boron	B
Hydrogen	H
Neon	Ne
Phosphorous	P
Oxygen	O

Name	Symbol
Helium	He
Radon	Rn
Chlorine	Cl
Bromine	Br
Iodine	I
Nitrogen	N

Names and Formulae of Molecules and Compounds

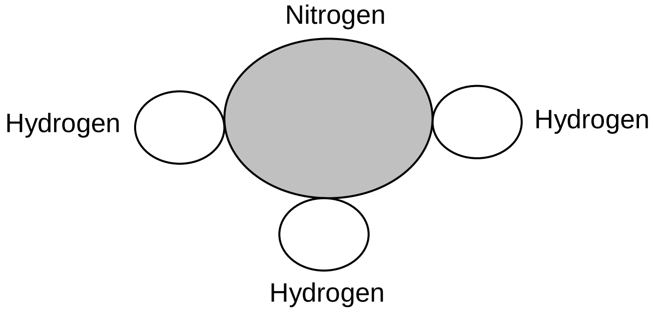
Molecules are composed of atoms of different elements combined in a fixed ratio. For example, the ratio of hydrogen atoms to oxygen atoms in a water molecule is 2:1.



A water molecule

The symbol for water is written as H_2O (read as 'H-2-O'). The 2 represents the number of hydrogen atoms in one molecule of the compound. The O represents the 1 atom of oxygen in the molecule. (We do not to write the number 1 against elements if there is only 1 atom of the element in the molecule).

As a second example, study the diagram of ammonia molecule shown below.



A molecule of ammonia

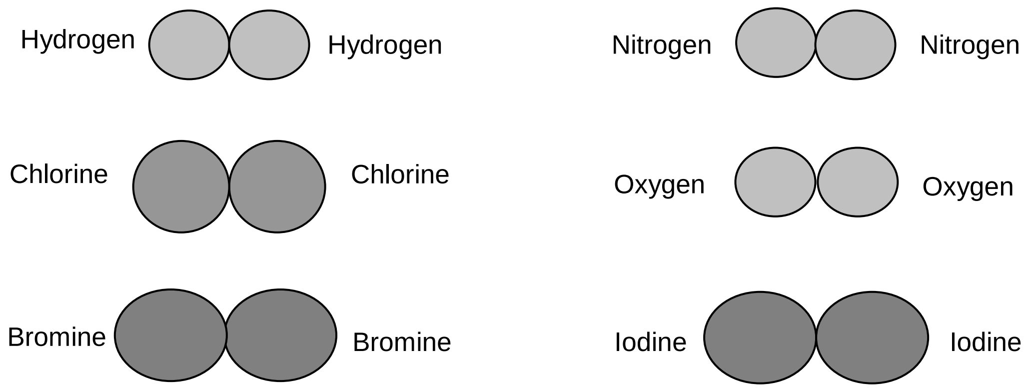
Since there is one nitrogen atom and three hydrogen atoms in a molecule of ammonia, the ratio of nitrogen atom to hydrogen atoms is 1:3.

We write the ratio of nitrogen as NH_3 (read as 'N-H-3'). The 3 represents the number of hydrogen atoms in one molecule of the compound. The N represents 1 atom of nitrogen in the molecule.

Formulae of Diatomic Molecules

Diatomic molecules* exist as molecules containing two atoms when they are not combined with other elements.

The gases hydrogen, oxygen, nitrogen and chlorine are diatomic molecules, as well the liquid bromine and the solid iodine.



The diatomic molecules: hydrogen, oxygen, nitrogen, chlorine, bromine and iodine

Since diatomic molecules contain two atoms, we show this by putting a small '2' a little lower and to the right of the element's symbol.

Thus hydrogen, oxygen, nitrogen, chlorine, bromine and iodine are represented in equations respectively as H_2, O_2, N_2, Cl_2, Br_2, and I_2 when they are not combined with other elements.

Do not confuse 2H with H_2 as 2H represents two separate atoms of hydrogen, but H_2 represents two atoms of hydrogen joined together to form a molecule of hydrogen, H_2.

All other elements are regarded as single atoms. So it would be wrong, for example to write sodium, when it is not combined with other elements as Na_2. It must be written as Na.

Names and Formulae of Metallic Compounds

The names of metallic compounds often ends in **-ide**. The metal in the compounds is named first, the non-metal follows, with ending changed to -ide.

For example, Iron sulphide: the non-metal sulphur, has its ending changed to sulphide. The formula for Iron sulphide is: FeS, which is read as ‘F-E-S”.
Another example is Sodium chloride (common salt). The non-metal chlorine has its ending changed to chloride. The formula for Sodium chloride is: NaCl, which is read as ‘N-A-C-L’.

Oxygen in compounds
The names of many compounds containing oxygen end with either **-ate** or **-ite**.
(i) -ate example Sodium chlorate $NaClO_3$ (read the formula as (‘N-A-C-L-O-3’).
(ii) -ite example Sodium chlorite $NaClO_2$ (read the formula as ‘N-A-C-L-O-2’). Chlorites contain a lesser amount of oxygen than similar compounds which end with -ate.

Other name endings of compounds
The endings **-ic** and **-ous** are often used with the name of either one or more of the elements the compound is derived from. Some acids ending with **-ic** are:
(i) Nitric acid: HNO_3 (read as ‘H-N-O-3’).
(ii) Hydrochloric acid: HCl (read as ‘H-C-L’).
(iii) Ferric chloride: $FeCl_3$ (read as ‘F-E-C-L-3’).
(iv) Cupric chloride: $CuCl_2$ (read as ‘C-U-C-L-2’).

The compounds ending with -ous generally contain fewer atoms than very similar compounds which end with -ic, for example:
(i) Ferrous chloride: $FeCl_2$ (read as ‘F-E-C-L-2’) has fewer atoms of chlorine than Ferric chloride $FeCl_3$.
(ii) Nitrous acid: HNO_2 (read as ‘H-N-O-2’) has fewer atoms of oxygen than Nitric acid HNO_3.

Note:
In some textbooks you may come across a different wording for ferric and ferrous compounds. Ferric chloride, for example may be called Iron (III) chloride and ferrous chloride may be called Iron (II) chloride.
Similarly, you may come across a different wording for cupric and cuprous compounds. Cupric chloride, for example may be called copper (II) chloride and cuprous chloride may be called Copper (I) chloride.

Prefixes used to name compounds
The prefix **per-**, for example, is used to show that a compound has more oxygen than those compounds whose names end with -ate. For example, Sodium perchlorate, $NaClO_4$ (read as ‘N-A-C-L-O-4’) has one oxygen atom more per molecule than sodium chlorate $NaClO_3$.

Further examples of compound names and formulae

Using the method of naming compounds you have just read about, here is a list of names and formulae of some other compounds.

Name	Formula
Calcium carbonate	$CaCO_3$
Sulphuric acid	H_2SO_4
Copper sulphate	$CuSO_4$
Potassium hydroxide	KOH

Name	Formula
Sodium sulphite	Na_2SO_3
Potassium chlorate	$KClO_3$
Potassium perchlorate	$KClO_4$
Calcium sulphide	CaS

Activity: **Now test yourself by doing this activity.**

Complete the following story by filling in the names of the elements in the blank spaces. The symbols in brackets are the chemical symbols of the elements.

The Komo kid mounted his trusty horse, old (Au) __________. He strapped his shooting (Fe) __________ to his side and headed out for the bright (Ne) __________ lights. He was determined to rob the stage coach of its precious (U) __________ load. He inhaled a deep breath of (O) __________ and coughed on the (S) __________ from the nearby factories. It was really hot; the (Hg) __________in the thermometer was rising. He took a drink of water and spat as he tasted the (Cl) __________.

He rode north, his bones aching from (Ca) __________ deposits built up from years of riding the (Zn) __________ trail. Overhead he saw a (He) __________ balloon in the sky. Soon he spotted the stage coach. It was guarded by an old sheriff with a (Sn) __________ badge. ‘Stop ‘, the kid yelled, ‘or I’ll fill you full of (Pb) __________. The sheriff went for his gun but was to slow, kid’s gun blazed like flaming (Mg) __________ and the (Cu) __________ fell to the ground. Anyone who drew on the kid should have known his life wasn’t worth a plugged (Ni) __________. A young girl screamed as the kid pulled out some (N) __________ compounds to blow the strong box.

Suddenly a shout rang out. ‘Hi Ho (Ag) _________. A masked man on the white horse raced across the (Si) __________ sands like (Na) __________ skittering on water. ‘There’s a (Rn) __________, he cried. The kid was captured and was put behind (Co) __________ steel bars.

Don’t let your life be a (C) __________ copy of the kid’s. Learn your Chemistry!

B. Highlight the names of the 18 common elements in the word search. Words may be horizontal, vertical, forward or backward.

I	N	C	O	P	P	E	R	S	T
N	O	A	N	E	G	Y	X	O	R
O	D	L	O	G	M	E	A	D	U
B	C	C	H	H	A	R	L	I	E
R	H	I	A	N	G	S	S	U	N
A	L	U	M	I	N	I	U	M	I
C	O	M	E	O	E	L	L	N	T
E	R	O	R	D	S	V	P	O	R
D	I	U	C	I	I	E	H	R	O
A	N	T	U	N	U	R	U	I	G
E	E	C	R	E	M	O	R	S	E
L	O	H	Y	D	R	O	G	E	N

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 8.

Summary

You have come to the end of lesson 8. In this lesson you have learnt that:

- John Dalton's theory states that:
  - all matter is composed of atoms.
  - atoms of the same element (a substance that cannot be divided into simpler substances) are identical in size and mass.
  - atoms of one element are different from atoms of another element.

  He used picture symbols to represent the elements he was studying.
- several years later a Swedish chemist, Berzelius, devised a more logical and efficient method of representing the elements, the one which we use today.
- some of the symbols are derived from the letters of the Latin language.
- many of the symbols are derived from the letters of English words.
- a few elements are named after the famous scientists.
- molecules are composed of atoms of different elements combined in a fixed ratio.
- di-atomic molecules exist as molecules containing two atoms when they are not combined with other elements.
- the names of metallic compounds often ends in -ide. The metal in the compounds is named first, the non-metals follows, with ending changed to -ide.
- the names of many compounds containing oxygen end with either -ate or -ite.
- the endings -ic and -ous are often used with the name of either one or more of the elements the compound is derived from.
- the prefix per-, for example, is used to show that a compound has more oxygen than those compounds whose names end with -ate.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

Answer the following questions:

1. Differentiate symbol from formula.

   a. Symbol

   ____
   ____
   ____

   b. Formula

   ____
   ____
   ____

2. Explain the rules in naming compounds.

   a.

   ____
   ____
   ____
   ____

   b.

   ____
   ____
   ____
   ____

   c.

   ____
   ____
   ____
   ____

   d.

   ____
   ____
   ____
   ____

   e.

   ____
   ____
   ____
   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to activity

Part A.

The Komo kid mounted his trusty horse, old (Au) g**old.** He strapped his shooting (Fe) **iron** to his side and headed out for the bright (Ne) **neon** lights. He was determined to rob the stage coach of its precious (U) **uranium** load. He inhaled a deep breath of (O) **oxygen** and coughed on the (S) **sulphur** from the nearby factories. It was really hot, the (Hg) **mercury** in the thermometer was rising. He took a drink of water and spat as he tasted the (Cl) **chlorine**.

He rode north, his bones aching from (Ca) **calcium** deposits built up from years of riding the (Zn) **zinc** trail. Overhead he saw a (He) **helium** balloon in the sky. Soon he spotted the stage coach. It was guarded by an old sheriff with a (Sn) **tin** badge. 'Stop ', the kid yelled, 'or I'll fill you full of (Pb) **lead** '. The sheriff went for his gun but was to slow, kid's gun blazed like flaming (Mg) **magnesium** and the (Cu) **copper** fell to the ground. Anyone who drew on the kid should have known his life wasn't worth a plugged (Ni) **nickel**. A young girl screamed as the kid pulled out some (N) **nitrogen** compounds to blow the strong box.

Suddenly a shout rang out. 'Hi Ho (Ag) **silver**'. A masked man on the white horse raced across the (Si) **silicon** sands like (Na) **sodium** skittering on water. 'There's a (Rn) **radon** (=raid on)' he cried. The kid was captured and was put behind (Co) **cobalt** steel bars.

Don't let your life be a (C) **carbon** copy of the kid's. Learn your Chemistry!

Part B. Highlight the names of the18 common elements in the word search. Words may be horizontal, vertical, forward or backward.

I	N	**C**	**O**	**P**	**P**	**E**	**R**	**S**	T
N	O	**A**	**N**	**E**	**G**	**Y**	**X**	**O**	R
O	**D**	**L**	**O**	**G**	**M**	E	A	**D**	U
B	**C**	**C**	H	H	**A**	R	L	**I**	E
R	**H**	**I**	A	N	**G**	**S**	**S**	**U**	**N**
A	**L**	**U**	**M**	**I**	**N**	**I**	**U**	**M**	**I**
C	**O**	**M**	**E**	**O**	**E**	**L**	**L**	**N**	**T**
E	**R**	O	**R**	**D**	**S**	**V**	**P**	**O**	**R**
D	**I**	U	**C**	**I**	**I**	**E**	**H**	**R**	**O**
A	**N**	T	**U**	**N**	**U**	**R**	**U**	**I**	**G**
E	**E**	C	**R**	**E**	**M**	O	**R**	S	**E**
L	O	**H**	**Y**	**D**	**R**	**O**	**G**	**E**	**N**

Lesson 9: Metals and Non-metals

From the previous lesson, you have studied about symbols and formulae. You have discussed the difference between symbol and formula and explained the rules in naming compounds. For this lesson you will study the difference between metals and non-metals.

Your Aims:

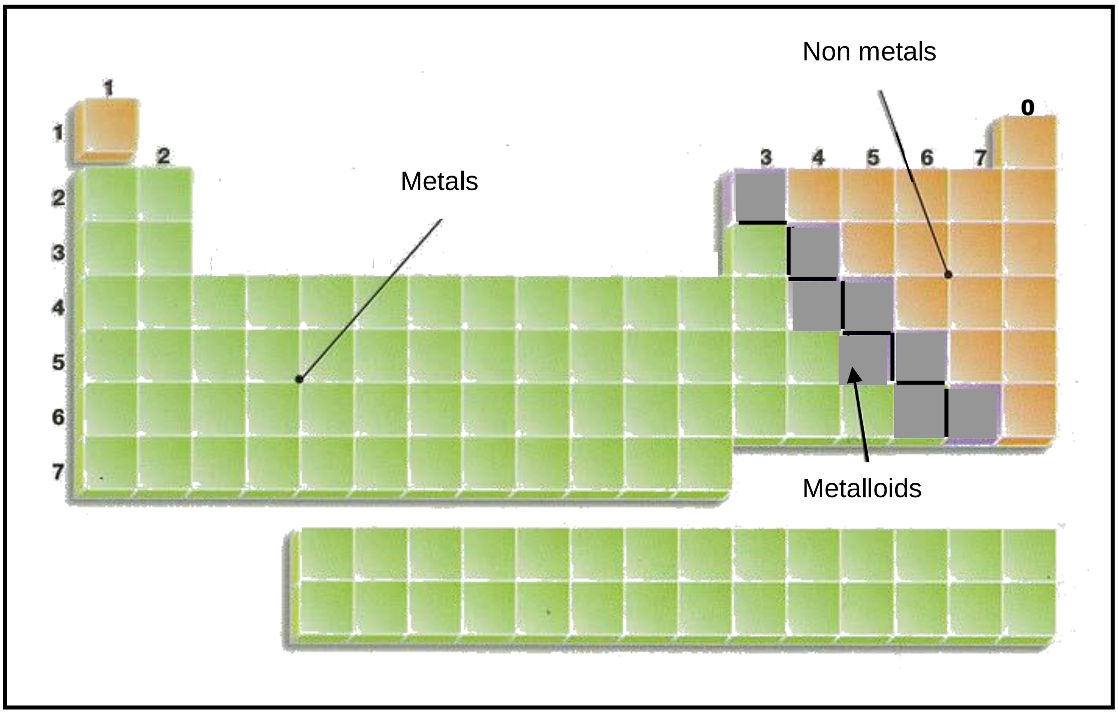
- differentiate metals from non-metals
- define and describe metalloid
- enumerate the properties of metals and non-metals

Classifying Elements

Elements are classified according to their properties. The major categories of elements are the metals, non-metals, and **metalloids***.

Metals

You see **metals*** every day. Aluminium foil is a metal. Gold and silver are metals. If someone asks you whether an element is a metal, metalloid, or non-metal and you do not know the answer; guess that it is a metal. Most elements are metals. There are so many metals, they are divided into groups: alkali metals, alkaline earth metals, and transition metals. The transition metals can be divided into smaller groups, such as the lanthanides and actinides.



Group 1: Alkali Metals

The alkali metals are located in Group 1 (**first column**) of the Periodic Table. Sodium and potassium are examples of these elements. Alkali metals form salts and many other compounds. These elements are less dense than other metals, form ions with a +1 charge, and have the largest atom sizes of elements in their periods. The alkali metals are highly reactive.

Group 2: Alkaline Earth Metals
The alkaline earth metlas are located in Group 2 (**second column**) of the Periodic Table. Calcium and magnesium are examples of alkaline earth metal. These metals form many compounds. They have ions with a +2 charge. Their atoms are smaller than those of the alkali metals.

Groups between 2 and 3: Transition Metals
The transition elements are located in Groups between 2 and 3. Iron and gold are examples of transition metals. These elements are very hard, with high melting points and boiling points. The transition metals are good electrical conductors and are very malleable. They form positively charged ions.

The transition metals include most of the elements, so they can be categorised into smaller groups. The lanthanides and actinides are classes of transition elements. Another way to group transition metals is into triads, which are metals with very similar properties, usually found together.

The iron triad consists of iron, cobalt, and nickel. Just under iron, cobalt, and nickel is the palladium triad of ruthenium, rhodium, and palladium, while under them is the platinum triad of osmium, iridium, and platinum.

Lanthanides
When you look at the Periodic Table, you will see there is **a block of two rows of elements** below the main body of the table. The top row has atomic numbers following lanthanum. These elements are called the lanthanides. The lanthanides are silvery metals that tarnish easily. They are relatively soft metals, with high melting and boiling points. The lanthanides react to form many different compounds. These elements are used in lamps, magnets, lasers, and to improve the properties of other metals.

Actinides
The actinides are in the **row below the lanthanides**. Their atomic numbers follow actinium. All of the actinides are radioactive, with positively charged ions. They are reactive metals that form compounds with most non-metals. The actinides are used in medicines and nuclear devices.

What are the Properties of Metals?

Metals share some common properties. These properties result from the ability to easily move the electrons in the outer shells of metal atoms. **Elements to the left of the zigzag line are metals or metal like elements**. Following are descriptions of the physical properties of metals:

- They are shiny (lustrous) when polished.
- They are good conductors of heat and electricity.
- They have high densities. That means they feel ‘heavy’ for their size.
- They have high melting and boiling points. (They are all solid at room temperature except mercury which is liquid.)
- They are ductile they can be drawn out into thin wires.
- They are malleable. That means they can be hammered into thin sheets and bent into shape without breaking.
- They are sonorous. That means they make a ringing sound when you strike them.

- They are strong under tension and compression. That means they can withstand crushing and stretching without breaking.

Chemical properties of metals:

- Easily lose electrons
- Corrode easily. Corrosion is a gradual wearing away. (Example: silver tarnishing and iron rusting).

All Metals are Different

The properties on the last page are typical of metals. But not all metals have all of these properties. For example:

Iron is a typical metal. It is used for gates like these because it is both malleable and strong. It is used for anchors because of its high density, but unlike most other metals, it ihas magnetic effects.

Sodium is quite different. It is so soft that it can be cut with a knife and it is so light that it floats on water. It reacts immediately with the water, forming a solution. It is not good for gates.

Gold melts at 1064^{o}C. Unlike most other metals it does not form an oxide- it is very unreactive. But it is malleable and ductile and looks attractive. So it is used for making jewellery.

What are Some Applications of Metals?

Metals are used in:

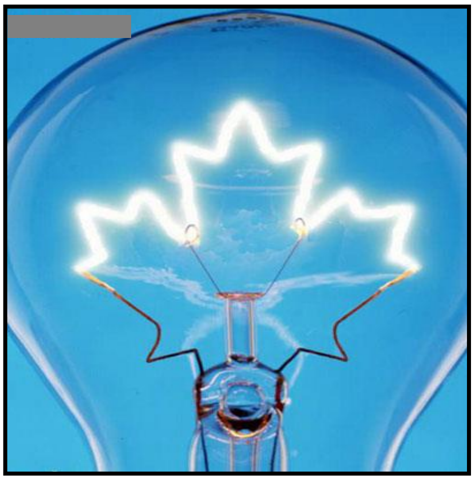
- Transportation - Cars, buses, trucks, trains, ships, and airplanes.
- Aerospace - Unmanned and manned rockets and the space shuttle.
- Computers and other electronic devices that require conductors (TV, radio, stereo, calculators, and security devices.
- Communications including satellites that depend on a tough but light metal shell.
- Food processing and preservation - Microwave and conventional ovens and refrigerators and freezers.
- Construction - Nails in conventional lumber construction and structural steel in other buildings.
- Biomedical applications - As artificial replacement for joints and other prostheses.
- Electrical power production and distribution - Boilers, turbines, generators, transformers, power lines, nuclear reactors, oil wells, and pipelines.
- Farming - Tractors, combines and planters..

- Household conveniences - Ovens, dish and clothes washers, vacuum cleaners, blenders, pumps, lawn mowers and trimmers, plumbing, water heaters, heating/cooling, etc.

Here is a list of some of the metallic elements you would be familiar with in everyday life, and their uses:

Metal	Use
Gold	Jewellery
Silver	Photographic film
Iron	Construction industry
Copper	Electric cable
Tin	Canned food
Aluminium	Aircraft bodies, cans and kegs
Mercury	Thermometers
Zinc	Torch batteries
Manganese	Strengthens steel example for bulldozer blades
Sodium	One ingredient of common salt
Magnesium	Camera flashbulbs
Calcium	Essential for healthy bones
Tungsten	Electric light filaments


Torch with battery


Tungsten filament inside an electric bulb

You will have noticed that a few names of these metals end with **-ium**. All elements apart from helium whose names end with -ium are part of the metallic group of elements.

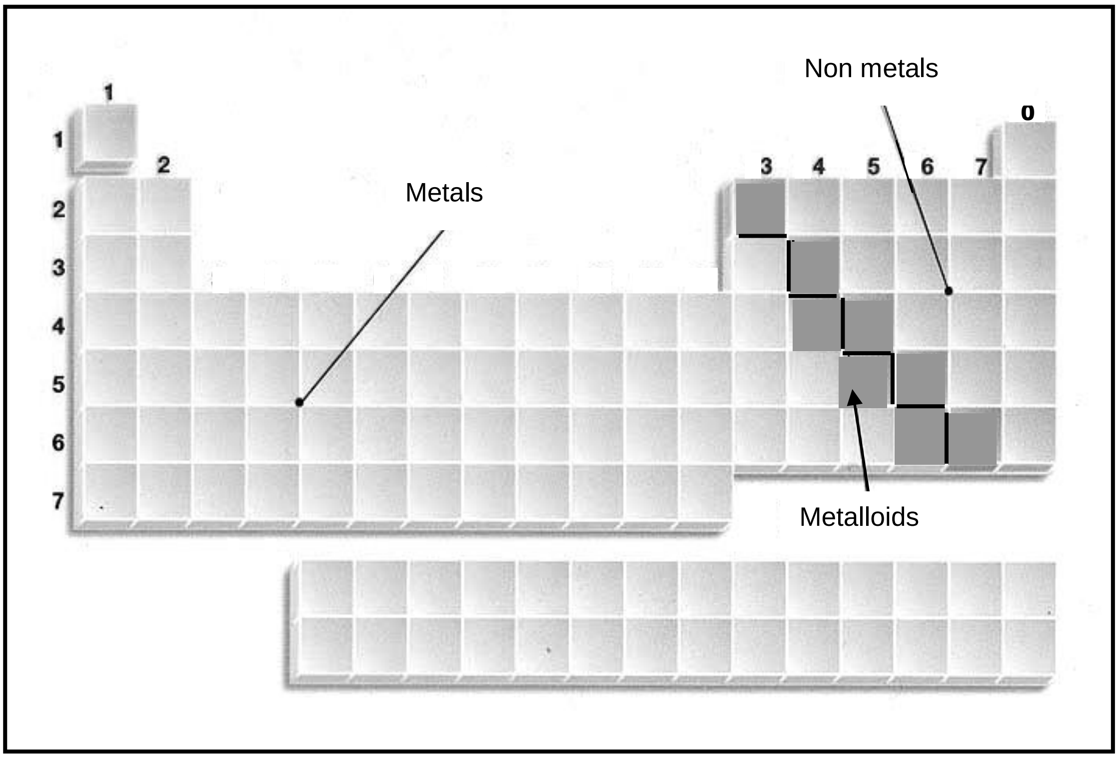
Metallic **alloys*** are not elements but are a mixture of elements. When zinc is mixed with copper, we obtain brass (often used for making screws). When iron and carbon are mixed, we obtain steel. Metallic alloys share many common properties with the metallic elements.

Non-metals and metalloids

Elements that do not have the properties of metals are called non-metals. Some elements have some, but not all of the properties of metals. These elements are called metalloids.

Non-metals

The non-metals are located on the upper right side of the Periodic Table, separated from metals by a zigzag line that cuts diagonally through the Periodic Table. Most non-metals gain electrons easily. Their characteristics are opposite those of metals. The non-metals can be divided into classes of elements that have similar properties. The halogens and the noble gases are two groups of non-metals.



Group 7: Halogens

The halogens are located in Group 7 of the Periodic Table. Examples of halogens are chlorine and iodine. You find these elements in bleaches, disinfectants, and salts. These non-metals form ions with a -1 charge. The physical properties of the halogens vary. The halogens are highly reactive.

Group 0: Noble Gases

The noble gases are located in Group 0 of the Periodic Table. Helium and neon are examples of noble gases. These elements are used to make signs, refrigerants, and lasers that glow in the dark. The noble gases are not reactive. This is because they have little tendency to gain or lose electrons.

Hydrogen

Hydrogen has a single positive charge, like the alkali metals, but at room temperature, it is a gas that does not act like a metal. Therefore, hydrogen usually is labelled as a non-metal.

Physical properties of non-metals

Only 21 of the elements are non-metals. Non-metals are quite different from metals. They usually have these properties.

- They are not strong, or malleable, or ductile, or sonorous. In fact when solid non-metals are hammered, they break up-they are **brittle**.
- They have lower melting and boiling points than metals.
- They are solids and gases at room temperature (25^oC), apart from bromine which is a liquid.
- They are poor conductors of heat and electricity. Graphite (carbon) is the only exception.
- They have low densities.
- They are not shiny

Chemical properties of non-metals

- They tend to gain electrons.
- Many of them dissolve in water to give acidic solutions.

Uses of Non-metals

Some of the non –metals are used in

- Water purification process
- Insulating material around wire cables since they do not conduct electricity.
- Making pan handles as they are poor conductors of heat.
- Fertilizers
- Respiration
- Crackers
- Ointments

Ammonium nitrate fertiliser

Antibiotic Ointment

Some of the non- metals are sulphur, oxygen, chlorine, hydrogen, bromine, nitrogen and helium.

Sulphur:

Sulphur is a non- metal used to prepare

- Sulphur drugs
- Sulphur compounds like sulphuric acid and sulphur dioxide .
- Matches, vulcanized rubber, dyes, and gunpowder

Oxygen:

Oxygen is a non- metal used for

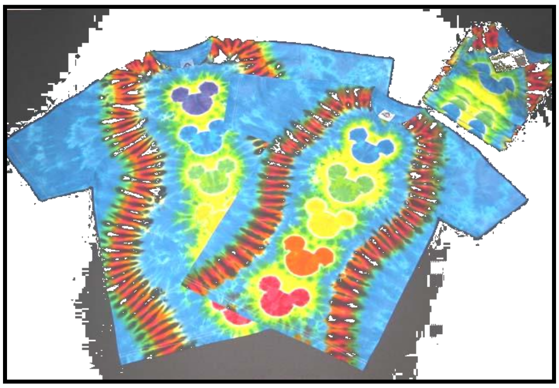
- Breathing
- Oxidation reactions
- Fire extinguishers

Chlorine:

Chlorine is a non- metal Used for

- Drinking water
- Dyestuffs
- Antiseptic

Chlorine used in drinking water



Dyed T-shirts

Below is a list of some non-metallic elements you would be familiar with followed by some of their uses.

Non-metal	Use
Oxygen	Essential for life
Nitrogen	Fertilizers
Hydrogen	Rocket fuels
Neon	Neon fluorescent lights
Chlorine	Disinfect water
Silicon	Computer chips
Carbon	Pencils
Helium	Weather balloons
Iodine	Iodised salt prevents goitre
Fluorine	Ingredient of toothpaste, helps prevent tooth decay
Sulphur	Tyre manufacturing

Sulphur is used in tyre manufacturing

Fluorine is used in toothpaste making

Unusual properties of carbon and silicon
Carbon in the form of graphite and silicon are two important non-metallic elements which, unusually, have the metallic properties of high melting and boiling points and are good conductors of electricity.

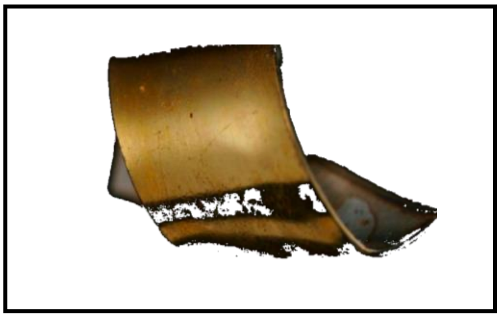
What are Metalloids?

Elements that have properties of both metals and non-metals are called metalloids. They can be shiny or dull and their shape is easily changed. Electricity and heat can travel through metalloids but not as easily as they travel through metals. They are located on both sides of the diagonal line between the metals and non-metals in the Periodic Table.

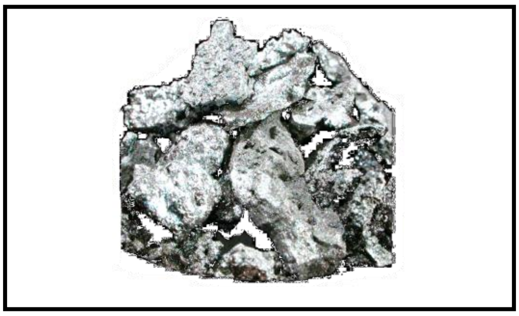
Silicon and germanium are examples of metalloids. The boiling points, melting points, and densities of the metalloids vary. The metalloids make good semiconductors.

Some of the examples of metalloids are:

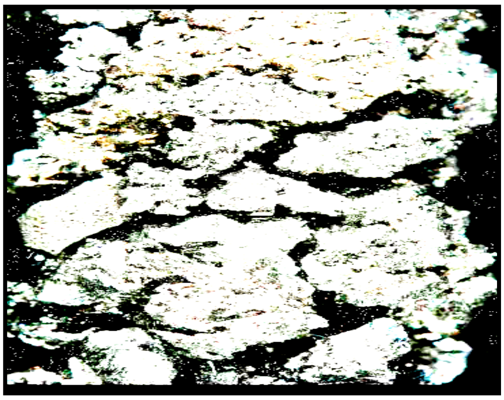
Boron	Germanium
Arsenic	Silicon
Antimony	Tellurium
Polonium	



Polonium



Boron



Arsenic

Silicon

Physical Properties of Metalloids
- Metalloids can be shiny or dull.
- Ductile –metalloids can be drawn into pipes.
- Malleable – metalloids can be beaten into sheets.
- It can conduct heat and electricity better than non-metals but not as well as metals. Metalloids are conductor of heat and electricity.

Chemical Properties of Metalloids

- Metalloids have variable chemical properties.
- They act like non-metals when they react with metals.
- They can act like metals when they react with non-metals.
- These materials also have 'semi-conductor' properties.

Uses of Metalloids

- Boron, Germanium and Arsenic are used in semiconductor chips.
- Silicon is the substrate for semiconductor chips.
- Ammonium nitrate is used in the manufacture of fireworks.
- Ammonium carbonate is used as a smelling salt.
- Metalloids are usually brittle, somewhat shiny solids that behave as electrical insulators at room temperature but become comparable to metals as electric conductor

COMPARISON BETWEEN METALS AND NON-METALS

Metals	Non- metals
Strong	Brittle
Malleable and ductile	Brittle
Sonorous	Dull sound when hit by hammer
High melting and boiling points	Low melting and boiling points
Good conductors of electricity	Poor conductors of electricity
Good conductors of heat	Poor conductors of heat
Mainly solids at room temperature except mercury which is liquid	Solids, liquids and gases at room temperature
Shiny when polished	Dull looking
High density	Low density

Activity: **Now test yourself by doing this activity.**

Circle the letter of the correct answer.

1. The property of metals by which they can be beaten into thin sheets is called

   A. ductility. B. conduction.

   C. expansion. D. malleability.

2. Which one of the following is metal?

A. C B. N

C. Na D. O

3. Which one of the following is a non-metal?

A. Zn B. Al

C. Fe D. N

4. All the materials shown has a property of malleability except

A. iron. B. silver.

C. graphite. D. aluminium.

5. Which one is a good conductor of electricity?

A. Iron B. Wood

C. Glass D. Plastic

6. The property of metal by which it can be drawn into wires is called

A. ductility. B. decorating.

C. conductivity. D. malleability.

7. The metals that produce a ringing sound are said to be

A. hard. B. lustrous.

C. sonorous. D. malleable.

8. Which metal is found in liquid state at room temperature?

A. Al B. Fe

C. Zn D. Hg

9. Which non-metal is essential for our life and inhale during breathing?

A. H B. O

C. C D. N

10. One uses of non-metals is for

A. aeroplanes B. fertilisers

C. water boilers D. making machinery

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 9.

Summary

You have come to the end of lesson 9. In this lesson you have learnt that:

- elements are classified according to their properties. The major categories of elements are metals, non-metals, and metalloids.
- elements to the left of the zigzag line of the Periodic Table are metals or metal like elements.
- metals are divided into groups: alkali metals, alkaline earth metals, and transition metals. The transition metals can be divided into smaller groups, such as the lanthanides and actinides.
- the alkali metals are located in Group 1 (first column) of the Periodic Table. Sodium and potassium are examples of these elements.
- the alkaline earth metals are located in Group 2 (second column) of the Periodic Table. Calcium and magnesium are examples of alkaline earth metals.
- the transition elements are located in Groups between 2 and 3. Iron and gold are examples of transition metals.
- the lanthanides are the top row elements below the main body of the table. They are silvery metals that tarnish easily. They are relatively soft metals, with high melting and boiling points.
- the actinides are in the row below the lanthanides. They are radioactive, with positively charged ions. They are reactive metals that form compounds with most non-metals. The actinides are used in medicines and nuclear devices.
- metallic alloys are not elements but are a mixture of elements. Metallic alloys share many common properties with the metallic elements.
- the non-metals are located on the upper right side of the Periodic Table, separated from metals by a zigzag line that cuts diagonally through the Periodic Table.
- the halogens and noble gases are two groups of non-metals.
- the halogens are located in Group 7 of the Periodic Table. Examples of halogens are chlorine and iodine.
- the noble gases are located in Group 0 of the Periodic Table. Helium and neon are examples of noble gases.
- hydrogen at room temperature is a gas that does not act like a metal. Therefore, hydrogen usually is labelled as a non-metal.
- elements that have properties of both metals and non-metals are called metalloids. They can be shiny or dull and their shape is easily changed.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Answer the following questions:

1. Differentiate and describe metals from non-metals.

 a. Metals

 b. Non-metals

2. Describe metalloid.

3. Give the uses of the following metals.

Metal	Uses
Nitrogen	
Hydrogen	
Sulphur	
Tungsten	
Mercury	
Aluminium	
Iron	

4. Answer the questions briefly.

 a. Which non-metal is in liquid state?

b. Which non-metal conducts heat and electricity?

c. Which metal is liquid at room temperature?

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to activity

1. D
2. C
3. D
4. C
5. A
6. A
7. C
8. D
9. B
10. B

Answers to Practice Exercise 6 - 9

1.

- The development of the Periodic Table began with German chemist Johann Dobereiner (1780-1849) who grouped elements based on similarities.
- In 1862, French geologist Alexandre-Emile Béguyer de Chancourtois listed the elements on paper tape and wound them, spiral like, around a cylinder. Certain 'threes' of elements with similar properties came together down the cylinder. He called his model the 'telluric screw'.
- In 1864, English chemist John Newlands noticed that, if the elements were arranged in order of atomic weight, there was a periodic similarity every 8 elements. He proposed his 'law of octaves' on this.
- In 1869, Lothar Meyer complied a Periodic Table of 56 elements based on a regular repeating pattern of physical properties such as molar volume. Once again, the elements were arranged in order of increasing atomic weights.
- Also in 1869, Russian chemist Dmitri Mendeleev produced a Periodic Table based on atomic weights but arranged 'periodically'. Elements with similar properties appeared under each other. Gaps were left for yet to be discovered elements.
- In 1894, William Ramsay discovered the noble gases and realised that they represented a new group in the Periodic Table.
- In 1914, Henry Moseley determined the atomic number of each of the known elements. He realised that, if the elements were arranged in order of increasing atomic number rather than atomic weight, they gave a better fit within the 'Periodic Table'. The modern Periodic Table is based on Moseley's Periodic Law (atomic numbers).
- In 1940, Glenn Seaborg artificially produced heavy mass elements such as neptunium. These new elements were part of a new block of the Periodic Table called 'actinides'.

2. Explain the following.

Periodic Law - The periodic law states that the repeating chemical and physical properties of elements change periodically with the elements' atomic numbers.

Law of Octaves - When elements are arranged in ascending order of their atomic weights, every eighth element had similar physical and chemical properties and resembled the first element in its properties.

Law of Triads - Nature contains triads of elements where the middle element has properties that are an average of the other two members of the triad when ordered by the atomic weight.

Practice Exercise 7

1. a. In the Periodic Table of elements, the rows from left to right are called period. All of the elements in a period have the same number of atomic orbitals. Every element in the top row (the first period) has one orbital for its electrons. All of the elements in the second row (the second period) have two orbitals for their electrons. It goes down the Periodic Table like that.

   The period of an element signifies the highest energy level an electron in that element occupies in an unexcited state. Generally, within a given period, the chemical activity of metals increases with the group number, while the chemical activity of non-metals within a given period decreases with the group number.

   b. When a column goes from top to bottom, it is called a group. The elements in a group have the same number of electrons in their outer orbital. Every element in the first column (group one) has one electron in its outer shell. Every element on the second column (group two) has two electrons in the outer shell. As you keep counting the columns, you will know how many electrons are in the outer shell. There are some exceptions to the order when you look at the transition elements.

   Properties within each individual group are similar, but nevertheless vary within a group. Generally chemical activity decreases as the period increases a non-metal group and increases as the period increases within a metal group. The first element in a group is always an active metal; the last is always an inactive non-metal.

2. a. The reactivity for both alkali and alkaline earth metals increases from top to bottom as the atoms get larger. Alkali and alkaline earth metals react to lose an outer electron/s to obtain a full outer shell. The further the electron/s is from the nucleus, the easier this is. So, the bigger the atom, the more reactive the metal will be.

   b. As you go down Group 0, the density or 'heaviness' of the gases increases. The density increases because the mass of the atoms increases.

   c. In halogens, the reactivity decreases from top to bottom as the atoms get larger. As the atoms get bigger, their outer shells get further from the nucleus. The force of attraction gets less so the element gets less reactive.

3. The outermost shell of an atom is called its Valence shell. The electrons of this outermost shell are involved during chemical combinations; electrons are either given out from the outermost shell, or accepted into the outermost shell, or shared with the electrons in the outermost shell of another element. Valence electrons of an atom are responsible for chemical reactions as they take part in them.

   Elements having same number of valence electrons in their atoms possess similar chemical properties. The number of valence electrons and valance shell in an atom determines its position in the Periodic Table. Elements having 1, 2 or 3 electrons in the valence shell are metals. Elements having 4 to 7 electrons in their valence shell are non-metals.

Practice Exercise 8

1. a. Symbol - The symbol of an element is a short way of representing an element. Examples are H, O, I, Cl, Br, N, K, C, Na, Cr, and Mn.

   b. Formula - A chemical formula is a way of expressing information about the atoms that constitute a particular chemical compound. It identifies each constituent element by its chemical symbol and indicates the number of atoms of each element found in each molecule of that compound. Examples are H_2, O_2, I_2, Cl_2, Br_2 N_2, CH_4, $C_6H_{12}O_6$, CO_2,and H_2O.

2. a. The names of metallic compounds often ends in -ide. The metal in the compounds is named first, the non-metals follows, with ending changed to -ide. For example, Iron sulphide: the non-metal sulphur, has its ending changed to sulphide. The formula for Iron sulphide is: FeS, which is read as 'F-E-S".

   b. The names of many compounds containing oxygen end with either -ate or -ite. Examples of -ate example Sodium chlorate $NaClO_3$ (read the formula as ('N-A-C-L-O-3') and -ite example Sodium chlorite $NaClO_2$ (read the formula as 'N-A-C-L-O-2').

   c. The endings -ic and -ous are often used with the name of either one or more of the elements the compound is derived from.

      Examples of –ic are Nitric acid: HNO_3 (read as 'H-N-O-3') and Hydrochloric acid: HCl (read as 'H-C-L').

   d. The compounds ending with -ous generally contain fewer atoms than very similar compounds which end with -ic, for example:

      Ferrous chloride: $FeCl_2$ (read as 'F-E-C-L-2') has fewer atoms of chlorine than ferric chloride $FeCl_3$ and Nitrous acid: HNO_2 (read as 'H-N-O-2') has fewer atoms of oxygen than nitric acid HNO_3.

   e. The prefix per-, for example, is used to show that a compound has more oxygen than those compounds whose names end with -ate. For example, Sodium perchlorate, $NaClO_4$ (read as 'N-A-C-L-O-4') has one oxygen atom more per molecule than sodium chlorate $NaClO_3$.

Practice Exercise 9

1. a. Metals are elements located at the left side of the zigzag line of the Periodic Table. They are shiny, strong, sonorous, high density, malleable, ductile, have high melting and boiling points, good conductors of heat and electricity and mainly solids at room temperature except mercury.

   b. Non-metals are elements located at the right side of the zigzag line of the Periodic Table. Its properties are the opposite of metals. They are brittle; have dull sound when hit by a hammer, low melting and boiling points, poor conductors of heat and electricity, dull looking, low density and solid, liquids and gases at room temperature.

2. Elements that have properties of both metals and non-metals are called metalloids. They can be shiny or dull and their shape is easily changed. Electricity and heat can travel through metalloids but not as easily as they travel through metals. They are located on both sides of the diagonal line between the metals and non-metals in the Periodic Table.

Silicon and germanium are examples of metalloids. The boiling points, melting points, and densities of the metalloids vary. The metalloids make good semiconductors.

3.

Metal	Uses
Nitrogen	Fertiliser
Hydrogen	Rocket fuels
Sulphur	Tyre manufacturing
Tungsten	Electric light filaments
Mercury	Thermometers
Aluminium	Aircraft bodies, cans and kegs
Iron	Construction industry

4.
a. Bromine is the non-metal in a liquid state.

b. Graphite (a form of carbon) conducts heat and electricity.

c. Mercury is the metal at room temperature.

REVIEW OF TOPIC 2: The Periodic Table

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 6: Development of the Periodic Table

- The development of the Periodic Table begins with German chemist Johann Dobereiner (1780-1849) who grouped elements based on similarities.
- In 1829 Dobereiner proposed the Law of Triads: Middle element in the triad had atomic weight that was the average of the other two members.
- Alexandre Beguyer de Chancourtois (1820-1886), published in 1862 a list of all the known elements. The list was constructed as a helical graph wrapped around a cylinder. Elements with similar properties occupied positions on the same vertical line of cylinder.
- English chemist John Newlands (1837-1898), having arranged the 62 known elements in order of increasing atomic weights, noted that after interval of eight elements similar physical/chemical properties reappeared. In 1863 he wrote a paper proposing the Law of Octaves where elements exhibit similar behaviour to the eighth element following it in the table.
- Russian chemist Dimitri Mendeleev (1834-1907) proposed arranging elements by atomic weights and properties. In 1871 Mendeleev revised the 17-group table with eight columns (the eighth group consisted of transition elements). This table exhibited similarities not only in small units such as the triads, but showed similarities in an entire network of vertical, horizontal, and diagonal relationships.
- Lord Rayleigh (1842-1919) and William Ramsey (1852-1916) greatly enhanced the Periodic Table by discovering the "inert gases."
- Henry Moseley (1887-1915) arranged the elements according to increasing atomic numbers and not atomic masses and some of the inconsistencies associated with Mendeleev's table were eliminated. The modern Periodic Table is based on Moseley's Periodic Law (atomic numbers).
- The last major change to the Periodic Table resulted from Glenn Seaborg's work in the middle of the 20th century. Starting with plutonium in 1940, Seaborg discovered transuranium elements 94 to 102 and reconfigured the Periodic Table by placing the lanthanide/actinide series at the bottom of the table.

Lesson 7: Periods and Groups in the Periodic Table

- The Periodic Table has eight groups of elements which are numbered, plus a block of transition metals.
- Some of the groups have special names:
  Group 1 is often called the alkali metals
  Group 2 is the alkaline earth metals
  Group 7 is the halogens
  Group 0 is the noble gases
- The zigzag line through the groups separates the metals from non-metals. The metals are on the left.
- When a column goes from top to bottom, it is called a group. The elements in a group have the same number of electrons in their outer orbital.

- The horizontal rows in the table are called periods. All of the elements in a period have the same number of atomic orbital. Every element in the top row (the first period) has one orbital for its electrons.
- Hydrogen (H) and helium (He) are special elements.
- As you go down Group 0, the density or ‘heaviness’ of the gases increases.
- In halogens, the reactivity decreases from top to bottom as the atoms get larger.
- For both alkali and alkaline earth metals, the reactivity increases from top to bottom as the atoms get larger.
- The outermost shell of an atom is called its Valence shell.
- Valence electrons of an atom are responsible for chemical reactions as they take part in them.
- The number of valence electrons and valance shell in an atom determines its position in the Periodic Table that is the group and period to which the element belongs.
- Elements having 1, 2 or 3 electrons in the valence shell are metals. Exception is H and He. Elements having 4 to 7 electrons in their valence shell are non-metals.
- The number of valence electrons is just how many electrons an atom has in its outer shell. All the elements in each Group (column) have the same number of electrons in their outer shells.

Lesson 8: Symbols and Formulae

- John Dalton’s theory states that:
  - All matter is composed of atoms.
  - Atoms of the same element (a substance that cannot be divided into simpler substances) are identical in size and mass.
  - Atoms of one element are different from atoms of another element.
- He used little picture symbols to represent the elements he was studying.
- Several years later a Swedish chemist, Berzelius, devised a more logical and efficient method of representing the elements, the one which we use today.
- Some of the symbols are derived from the letters of the Latin language.
- Many of the symbols are derived from the letters of English words.
- A few elements are named after the famous scientists.
- Molecules are composed of atoms of different elements combined in a fixed ratio.
- Diatomic molecules exist as molecules containing two atoms when they are not combined with other elements.
- The names of metallic compounds often ends in -ide. The metal in the compounds is named first, the non-metals follows, with ending changed to -ide.
- The names of many compounds containing oxygen end with either -ate or -ite.
- The endings -ic and -ous are often used with the name of either one or more of the elements the compound is derived from.
- The prefix per-, for example, is used to show that a compound has more oxygen than those compounds whose names end with -ate.

Lesson 9: Metals and Non-metals

- Elements are classified according to their properties. The major categories of elements are the metals, non-metals, and metalloids.
- Elements to the left of the zigzag line of the Periodic Table are metals or metal like elements.
- Metals are divided into groups: alkali metals, alkaline earth metals, and transition metals. The transition metals can be divided into smaller groups, such as the lanthanides and actinides.

- The alkali metals are located in Group 1 (first column) of the Periodic Table. Sodium and potassium are examples of these elements.
- The alkaline earth metals are located in Group 2 (second column) of the Periodic Table. Calcium and magnesium are examples of alkaline earth metals.
- The transition elements are located in Groups between 2 and 3. Iron and gold are examples of transition metals.
- The lanthanides are the top row elements below the main body of the chart. They are silvery metals that tarnish easily. They are relatively soft metals, with high melting and boiling points.
- The actinides are in the row below the lanthanides. They are radioactive, with positively charged ions. They are reactive metals that form compounds with most non-metals. The actinides are used in medicines and nuclear devices.
- Metallic alloys are not elements but are a mixture of elements. Metallic alloys share many common properties with the metallic elements.
- The non-metals are located on the upper right side of the Periodic Table, separated from metals by a zigzag line that cuts diagonally through the Periodic Table.
- The halogens and the noble gases are two groups of non-metals.
- The halogens are located in Group 7 of the Periodic Table. Examples of halogens are chlorine and iodine.
- The noble gases are located in Group 0 of the Periodic Table. Helium and neon are examples of noble gases.
- Hydrogen at room temperature is a gas that does not act like a metal. Therefore, hydrogen usually is labelled as a non-metal.
- Elements that have properties of both metals and non-metals are called metalloids. They can be shiny or dull and their shape is easily changed

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REVISE WELL AND THEN DO TOPIC TEST 2 IN YOUR ASSIGNMENT 4.

GLOSSARY

Atoms	The basic building blocks of ordinary matter.
Matter	Anything which takes up space and has mass.
Physical change	Does not produce a new substance.
Chemical change	Produces new substance. The new substance is different from the original.
Nucleus	Located at the centre of the atom which is a cluster of protons and neutrons. The nucleus makes up almost all of an atom's mass or weight.
Elements	Substances that cannot be broken down or decomposed into simpler substances.
Compound	Substance formed when two or more elements are chemically joined.
Mixtures	Two or more substances that are mixed together but not chemically joined.
Homogeneous	Mixture has the same uniform appearance and composition throughout.
Heterogeneous	Mixture consists of visibly different substances or phases
Solution	Mixture of two or more substances in a single phase
Electrons	Tiny and very light particles that have a negative electrical charge
Protons	Larger and much heavier particles than electrons and have a positive charge
Neutrons	Large and heavy like protons; however they have no electrical charge.
Colloid	Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size
Suspension	A heterogeneous mixture in which solute-like particles settles out of solvent-like phase sometime after their introduction
Solution(s)	Mixture of two or more substances in a single phase.
Law of Triads	It was the classification of elements into groups of three elements each with similar properties such that the atomic weight of the middle element was the arithmetic mean of the other two example *Ca, Sr, Ba, Cl, Br, I* and so on.

Law of Octaves	It was an arrangement of elements in order of increasing atomic weights in which it was observed that every eighth element had properties similar to those of the first just like the eighth node of an octave of music.
Group	Also called a family, and runs in columns. All the elements in a group share the same characteristics. For example, Group 18: *The Noble Gases*, do not react with any other elements. There are 18 groups.
Period	All of the rows from left to right at a Periodic Table. All of the elements in a period have the same number of atomic orbital. There are 7 periods.
Transition metals	Any metallic elements between groups 2 and 3 in the Periodic Table. All the transition metals have two electrons in their outermost shell, and all but zinc, cadmium, and mercury have an incompletely filled inner shell (just inside the outermost shell). Transition elements form alloys easily, have high melting points, and have more than one valence because of their incomplete inner shells.
Diatomic molecules	Diatomic molecules are molecules formed of two atoms of the same element. Diatomic elements are those that almost exclusively exist as diatomic molecules in their natural elemental state, not chemically bonded with other elements. Examples include H_2 and O_2. Diatomic elements rarely exist in their atomic form.
Metals	Any of a category of electropositive elements that usually have a shiny surface, are generally good conductors of heat and electricity, and can be melted or fused, hammered into thin sheets, or drawn into wires.
Non-metals	Any of a number of elements, such as oxygen or sulphur, that lack the physical and chemical properties of metals.
Alloy(s)	A homogeneous mixture or solid solution of two or more metals, the atoms of one replacing or occupying interstitial positions between the atoms of the other: *Brass is an alloy of zinc and copper.*
Metalloids	An element with properties intermediate between those of a metal and non-metal.

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FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General/Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics -General/Advance	Mathematics -General/Advance	Mathematics –General/Advance
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.